THE RELATIONSHIP BETWEEN NEUROPSYCHOLOGICAL PERFORMANCE AND DAILY FUNCTIONING IN INDIVIDUALS WITH ALZHEIMER'S DISEASE

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The results of neuropsychological tests are often used by clinicians to make important decisions regarding a demented patient's ability to competently and/or independently perform activities of daily living. However, the ecological validity of most neuropsychological instruments has yet to be adequately established. The current study examined the relationship between neuropsychological test performance and functional status in 42 individuals diagnosed with Alzheimer's Disease. A comprehensive battery of cognitive tests was employed in order to assess a wide range of neuropsychological abilities. Functional status was measured through the use of both a performance-based scale of activities of daily living (The Direct Assessment of Functional Status; Loewenstein et al., 1989) as well as by a caregiver/informant-based rating scale (Instrumental Activities of Daily Living; Lawton & Brody, 1969). Findings suggest that neuropsychological functioning is moderately predictive of functional status. Memory performance was the best predictor of functional status in most ADL domains, followed by executive functioning and visuospatial abilities.

TABLE OF CONTENTS

LIST OF TABLES

THE RELATIONSHIP BETWEEN NEUROPSYCHOLOGICAL PERFORMANCE AND DAILY FUNCTIONING IN INDIVIDUALS WITH ALZHEIMER'S DISEASE

Alzheimer's Disease (AD) is a degenerative brain disorder which results in multiple cognitive deficits, the most notable of which is memory dysfunction. It primarily affects individuals over the age of 65, with risk for the disease increasing exponentially with advancing age (Cummings, 1994). Currently, there are an estimated four million Americans who are diagnosed with AD (National Institute of Health and National Institute of Aging, 1994). With the rapidly increasing number of older adults in our society, the number of people with AD is likely to continue to grow. Unfortunately, marked functional declines accompany the cognitive deficits associated with AD. Therefore persons with this disease are likely to show deficits in their capacity for self-care and ability to engage in activities of daily living. In fact, a recent study found that impairment in functional status was observed at all stages of AD, with increasing functional impairment occurring as the disease progressed (Eisdorfer et al, 1992). As a result, not only are neuropsychologist being asked to aid in the diagnosis of AD, but they are also being requested to evaluate the extent to which cognitive declines are associated with functional decline in activities of daily living (ADL). However, the relationship between performance on a battery of neuropsychological tests and the ability to function in real-life settings has yet to be clearly established. There has begun to be a body of literature that addresses this relationship; in particular, several studies have been conducted in which cognitive functioning was used to predict daily living skills in various geriatric populations. However, results are, thus far, difficult to interpret for a number of reasons including the use of varying neuropsychological and functional measures from study to study, as well as the inclusion of heterogeneous patient populations. The current study seeks to add to the literature base by further investigating the relationship between a battery of neuropsychological measures and functional competency in a group of well diagnosed AD patients. Functional abilities will be measured both by a performance-based instrument and by care-giver ratings of functional status.

The current paper begins by outlining one of the current diagnostic classification systems for AD, followed by a discussion of the pathophyisological characteristics and neuropsychological deficits that typically accompany the disorder. Issues relating directly to ecological validity will then be discussed followed by a review of the literature pertaining to the prediction of functional status based on neuropsychological performance in various geriatric populations. Finally, a detailed description of the current study is provided.

Diagnostic Criteria for Alzheimer's Disease

Alzheimer's Disease (AD) is a progressive neurodegenerative disorder that is associated with characteristic clinical and pathological features. The etiology of this disease is currently unknown although several risk factors have been identified. There are currently no available biological markers of AD that allow definitive premorbid diagnosis (Cumming & Khachaturian, 1996). Until such a marker is available, the clinician must rely on the application of diagnostic criteria based on the clinical symptomatology. There are two criteria-based systems used to diagnose AD in living individuals: the Diagnostic and

Statistical Manual of Mental Disorders, Forth Edition (DSM-IV; American Psychiatric Association, 1994) and the National Institution of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association Work Group (NINCDS-ADRDA; McKhann, Drachman, Folstein, Katzman, Price & Stadlan, 1984). The NINCDS-ADRDA diagnostic criteria has been widely adopted by researchers in the United States as it has been shown to have the highest reliability when compared to other diagnostic systems (Kukull, Larson, Reifler, Lampe, Yerby, & Hughes, 1990). The accuracy of clinical diagnosis using the NINCDS-ADRDA criteria has been reported to range from 86% to 92% (Loewenstein & Rubert, 1992). In order to increase diagnostic specificity and to facilitate comparisons with other studies, the present study employed the NINCDS-ADRDA diagnostic guidelines in selecting participants.

According to the NINCDS-ADRDA diagnostic system, possible, probable, and definite AD are defined. *Probable* AD is characterized by: 1) dementia by clinical exam and documented by the MMSE (or similar instrument) and confirmed by neuropsychological testing, 2) deficits in two or more areas of cognition, 3) progressive worsening in memory and other cognitive functions, 4) no disturbances of consciousness, 5) onset between the ages of 40 and 90 years, and 6) the absence of systemic disorders or brain disease that could account for the progressive cognitive deficits. Features which support the diagnosis of AD include progressive deterioration of specific functions such as language (aphasia), motor skills (apraxia), and perception (agnosia); impaired activities of daily living and altered patterns of behavior; family history of similar disorder; and evidenced based on laboratory results such as CT scan. Features which make the diagnosis of probable AD uncertain or unlikely include sudden onset, focal neurological signs, and seizure and/or gait disturbances early in the course of the disorder.

The diagnosis of *possible* AD is made in three cases. Such a diagnosis may be made if the patient has a dementia syndrome with no apparent cause but there are variations in the onset, presentation, or clinical course compared to typical AD. Secondly, this diagnosis can be made when the patient has a second neurological disorder or systemic illness sufficient to produce dementia but not considered to be the primary cause of the dementia. Possible AD is also diagnosed when the patient has a single gradually progressive deficit in the absence of any other identifiable cause.

Finally, definite AD requires that the patient has met clinical criteria for probable AD while living, and has histopathological evidence of markers upon biopsy or autopsy. As such, in most cases this is a post-mortem diagnosis.

Pathophysiology of Alzheimer's Disease

AD is characterized by widespread changes in both the neocortex and the limbic cortex, while the brain stem, cerebellum, and spinal cord are left relatively spared (Kolb & Whishaw, 1996). Gross inspection of the brains of individuals with AD reveal atrophy, most predominately in the temporo-parietal and anterior frontal regions with sparing of the primary motor and sensory cortices (Cummings & Benson 1992).

The main neuropathological findings in AD are neurofibrillary tangles and neuritic plaques. The neuritic plaques consist of a central core of protein material (amyloid) surrounded by degenerative cellular fragments. Plaques are found most densely in the hippocampus and tempro-parietal cortices. Increased concentration of neuritic plaques has been correlated with the magnitude of cognitive deterioration (Morris et. al., 1994). Neurofibrillary tangles represent intracellular accumulations of paired helical filaments are found predominately in the cerebral cortex and the hippocampus (Morris et al., 1994). The density and distribution of the neuritic plaques and neurofibrillary tangles are considered the only definitive biological markers of AD at this time (Albert & Moss, 1988). However, both healthy elderly individuals and those with AD can have some plaques and tangles. Therefore, neuropathological criteria for AD require that the concentration of neuritic plaques and tangles exceed predetermined cut off values, which increase with the age of the individual (Zec, 1993).

Numerous imaging studies have indicated that neuroanatomical structural changes often accompany AD. For example, CT studies have shown significant atrophy of the medial temporal lobe structures. Similar findings have also been reported using MRI scanning. (Morris, et al., 1994). However, in many AD patients, particularly those over 80 years of age, cerebral volume and atrophy are often within normal limits for age (Hubbard & Anderson, 1981). SPECT imaging studies have frequently sited a rather characteristic temporo-parietal deficit (Claus et al., 1994).

Reductions in several of the neurotransmitter systems have also been noted in association to AD. The nucleus basalis of Meynert in the basal forebrain is a site of a significant degree of neurofibrillary tangle formation (Whitehouse, Price, Struble, Clark, Coyle, & DeLong, 1982). This region is important because it is the site of cholinergic input to the cortex. Loss of cholinergic supply and choline acetyle transferase in the cerebral cortex is one of the most well-established neurochemical changes associated with AD (Davies & Maloney, 1976). Although the loss of cholinerigicactivity is not regarded as the primary cause of AD, reduced activity in these pathways is likely to contribute to at least some of the cognitive deficits associated with this disorder (Becker, 1991). Other neurotransmitters that also appear to be reduced in AD include serotonin and noradrenalin (Tomlinson, 1989; Mann et al., 1980).

Areas of Neuropsychological and Behavioral Dysfunction in AD

The pathophysiological changes associated with AD result in a rather consistent patterns of cognitive and behavioral disturbances. The following section briefly reviews the various areas of cognitive functioning that are typically impaired in this population.

Memory and Learning. Memory impairment is reported to be the most common presenting problem in individuals who are later diagnosed with AD. Memory difficulties tend to begin insidiously and progress gradually. They are typically a prominent and disproportionate feature of AD throughout most of the course of the disorder. However, by the middle stages of the disease memory deficits may show a floor effect on most of the availability standardized tests of memory (Zec, 1993).

The specific memory impairment in AD is characterized by the inability to learn new material; in essence, these individuals evidence an amnestic memory dysfunction (Cummings & Benson, 1983). Immediate recall of both verbal and nonverbal material is impaired (Albert & Moss, 1988). For example, on tests of immediate free recall of either meaningful material (sentences or stories) or on rote learning tasks (verbal paired-associate learning), AD patients demonstrate significant impairment (Delis, et al., 1991). Recall is not improved markedly by semantic or phonemic cueing (Cummings, 1986).

Delayed recall or long term memory is also deficient in AD very early in the course of the disorder. Long term memory can be defined as memory for information presented a minimum of 30 seconds prior to recall; most neuropsychological tests utilize a delay of 20-30 minutes (Miller & Morris, 1993). AD patients are impaired on a wide range of tasks involving long term memory which include: the delayed recall of word lists, sentences, and stories (Albert & Moss, 1988). The rate of forgetting becomes more rapid as the disease progresses (Zec, 1993). Delayed recall is the most sensitive measure to mild or early AD which is thought to be due to the fact that it reflects both a failure to learn over repeated trials and a failure to retain information over time (Welsh, Butters, Hughes, Mohs & Heyman, 1991).

Additionally, AD patients' memory is not significantly improved with the use of a recognition format wherein the individual does not have to freely recall bits of information but must just be able to recognize it when it is presented to them (Wilson, Bacon, Fox & Kaszniak, 1983). The poor performance of AD patients on recognition tasks is reflected in their inability to discriminate between the target and distractor items resulting in a high number of false positive responses. Recognition of both verbal and nonverbal information has been found to be deficient in persons with AD (Albert & Moss, 1988). Poor performance on recognition memory tests is thought to indicate a failure to learn and store new information (Zec, 1993).

Confabulation and intrusional errors are also characteristic features of the memory deficit associated with AD (Miller & Morris, 1993). A confabulation error involves the unintentional fabrication of material. Instead of correctly recalling information or even omitting material, AD individuals will often add new information that was not originally included. This type of error is elicited in response to a particular memory cue and represent an attempt to reconstruct that memory.

Attention and Concentration. Visual and verbal attention span and sustained attention often remains relatively intact in individuals with AD, especially in the early stages of the disease. For example, performance on letter cancellation tasks are often within normal range in mildly demented AD patients (Zec, 1993). Digit Span Forward is also likely to be within normal limits for individuals with mild to moderate stages of AD. However, as the disease progresses attentional abilities are eventually compromised (Albert & Moss, 1988).

Language. Language impairments are considered a fairly sensitive indicator of cortical dysregulation and AD is characterized by a specific pattern of linguistic deficits (Cummings, 1983). Alzheimer's patients commonly develop word finding deficits; that is, they demonstrate difficulties with the confrontational naming of objects, pictures, and people (Miller & Morris, 1993). In addition, they tend to make circumlocution errors in which an object is described instead of named, in order to compensate for being unable to recall its proper name. In the early stages of AD, deficits in naming are mild and occurs only in the case of low-frequency words, however as the disease progresses anomia becomes more severe (Zec, 1993; Miller & Morris, 1993; Cummings, 1983). Semantic paraphasias are also a characteristic feature of the disease. This type of error occur when the correct name of an object is replaced with a word that has a similar meaning (e.g. “harmonica” for “accordion”) (Albert & Moss, 1988). As the disease progresses verbal paraphasias become increasingly less related to the target word (Cummings, 1983). Eventual deficits in naming may be more related to perceptual problems, wherein the object is simply not recognized properly (Zec, 1993). Phonetic paraphasias are generally thought to be uncommon in the speech of Alzheimer patients. Due to the circumlocutions and paraphasias the speech of AD patients typically conveys little informational content and is often described as “empty.”

Generative naming or verbal fluency has also been found to be significantly deflated in individuals with AD (Cummings, 1983). In fact, verbal fluency tasks (along with episodic memory tests) are among the most sensitive measures for differentiating normal aging from mild AD (Storandt, Botwinick, Danziger, Berg & Hughes, 1984) and have also been found to correlate with the severity of dementia (Bayles, Kaszniak & Tomoeda, 1987). Verbal fluency tasks require an individual to generate as many items as possible in a limited period of time that belong to a given category. For example, the individual may be asked to generate words that begin with “F” (phonetic word fluency) or items found in a grocery store (semantic word fluency). Such tasks are considered measures of language, as well as semantic memory and executive functioning. Early in the course of AD, patients are found to generate fewer appropriate words than normal subjects. Semantic word fluency tasks are considered to be more useful than phonemic word fluency tests in differentiating AD patients from normal controls. However, phonemic word fluency tests are useful in eliciting intrusional errors (Zec, 1993).

Other language impairments in AD include reading comprehension and writing abilities

(Zec, 1993). Some aspects of language functions are preserved well into the course of AD. The simple repetition of phrases or sentences is usually preserved until the last stages of the disorder. Although the verbal output of AD patients may be reduced, the grammatical structure of their speech is generally intact (Zec, 1993). Furthermore, AD patients do not typically exhibit difficulties in articulation (dysarthria) (Albert & Moss, 1988; Miller & Morris, 1988). Lastly, the ability to read out-loud is often spared for quite some time (Fuld, Katzman, Davis, & Terry, 1982). It should be noted that eventually virtually all aspects of language are compromised; as the disease enters the final stages global aphasia may be evident (Zec, 1993).

Visual-spatial Functioning. Visual-spatial deficits are often impaired early in the course of AD (Cummings, 1983) and appear to increase with the severity of the disease (Bayles et al , 1987). Disturbances of constructional ability can be evaluated using Block Design or a variety of drawing and copying tasks. Block Design is usually impaired in individuals with moderate to severe AD; furthermore, performance on this task shows progressive deterioration over the course of the illness (Zec, 1993). Drawing tests have also been found to be useful in eliciting constructional deficits within the AD population. (Albert & Moss, 1988). Generally, more complex drawing tasks such as the copy portion of the Rey-Osterreith Figure will evidence constructional impairments before impairments are observed in copying less complex drawings such as the Greek Cross. However, even mildly demented AD patients show significantly more errors than age-matched controls on such tasks as the Bender-Gestalt (Zec, 1993).

Spatial disorientation, also referred to as geographical or topographical disorientation, is a form of visual agnosia that is often observed in individuals with AD (Zec, 1993). These patients tend to wander, get lost, and have difficulty locating familiar objects in the home. Disorientation while driving is often one of the first signs of the disease; as the illness progresses patients may even become confused in their own homes (Cummings, 1983). Spatial disorientation may result from both visual-perceptual deficits as well as impaired visuospatial memory (Zec, 1993).

Praxis. Apraxia is considered one of the hallmarks of this disease and two types of apraxic disorders are evident in patients with AD (Cummings, 1983). Ideomotor apraxia is frequently observed and entails the inability to carry out a simple motor act in response to verbal instruction. For example, a patient may be unable to demonstrate how a key is used. Ideational apraxia is also often observed and is the failure to carry out a hierarchical series of complex movements. For example, a person may be unable to demonstrate the motor steps needed to fold a piece of paper. Types of errors committed by AD patients on ideational apraxia tasks include both incorrectly executed movements and sequencing errors. Apraxic deficits usually appear in the middle to late stages of the disease, and are thought to be related to dysfunction of the parietal lobes (Zec 1993). Ideomotor apraxia is not thought to have a major impact on everyday function. However, ideational apraxia, because it can be involved with the impaired use of tools, has been hypothesized to adversely affect functioning in the home (Zec, 1993).

Problem Solving, Judgment and Abstraction. It is generally believed that problem solving is impaired relatively early in the course of AD. However, this area of neuropsychological functioning has not been as widely studied as memory, language and visuospatial abilities in the AD population. Research has shown that Alzheimer patients often evidence impaired abstract reasoning and judgment on the WAIS-R Similarities and Comprehension subtests (Albert & Moss, 1988). Due to the cortical degeneration of the frontal lobes that is associated with AD, these patients also exhibit symptoms associated with the frontal lobe dysfunction such as difficulty in initiation, problem-solving, set maintenance, and perseverative behavior (Paulsen et al, 1995).

Awareness of Deficits. Anosognosia is an impairment in the ability to accurately recognize the presence or appreciate the severity of one's cognitive deficits. The condition is neurologically based and results from various diseases or brain injury (Heilman, 1990). At least partial lack of awareness of deficits has been reported to be a common feature of AD (Kotler-Cope & Camp, 1995; Zec, 1993; DeBettingnies, Mahurin, Pirozzolo, 1990). In studies of AD patients, anosognosia has often been operationally defined as the discrepancy between self-reported cognitive functioning and caregiver ratings of functioning. For example, McGlynn & Kaszniak (1991) reported that AD patients significantly underestimated their cognitive problems in daily life compared with the ratings made by relatives. Furthermore, the discrepancy between self-report and relative-ratings of functioning was found to increase with the severity of dementia. The authors of this study suggest that findings are consistent with a breakdown in metacognitive processes or executive functioning which results in self-monitoring difficulties.

Affective and Behavioral Disturbances. Symptoms of depression are common among individuals with AD (Parks et al., 1993). In particular, symptoms most often include mood disturbances (including dysphoria and irritability), changes in activity patterns (including increased motor activity and decreased spontaneous participation in activities), and sleep alterations. Additionally, loss of interest in previously enjoyed activities, passivity, loss of concern, and reduced spontaneity are commonly seen in AD patients (Bozzola, Gorelick, Freels, 1992). There is some evidence to suggest that depression may be more common in mildly impaired patients, relative to more severely impaired AD patients (Reifler, Larson, Hanely, 1982). However, not all studies have confirmed this finding (Parks et al., 1993).

In addition to depression, other psychiatric symptoms are also frequently encountered in the AD patient. For example, paranoia, hallucinations and delusions have been reported as fairly common psychiatric symptoms associated with AD disease (Gilley, 1993). Delusions in AD are most typically persecutory ideas reflecting accusations of theft or malicious intent (Parks et al., 1993). Other behavioral problems are also seen in individuals with AD, particularly as the disease progresses, these can include apathy, agitation and combativeness, irritability, wandering, and inappropriate patterns of activity, including inappropriate sexual activity and repetitive, purposeless behaviors (Zec, 1993).

Ecological Validity and General Research Findings

Several authors have commented on the trends in the field of neuropsychology over the decades. During the early years, as the field was just emerging, the focus was diagnostic in nature and the validity of neuropsychological tests was judged in terms of their ability to identify brain dysfunction (Chelune, 1985; Hart & Hayden, 1986). As a result, neuropsychological assessment became widely recognized for its diagnostic utility across a variety of neuropathological conditions. Even today, neuropsychological assessment remains important in the identification and documentation of cerebral dysfunction, especially for particular conditions such as early dementia and mild head injury. However, traditional concerns with detecting and localizing brain lesions are becoming less important as brain structure and physiological functioning can be measured with new and widely available brain imaging techniques (Heinrichs, 1990). Thus, diagnostic questions are being replaced by new referral questions; in particular, neuropsychologist are now being frequently asked to predict the effects of the brain dysfunction on an individual's ability to function in everyday life (Hart & Haden, 1986). This is especially true in the case of the neuropsychological assessment of geriatric patients where clinicians are often asked to answer questions pertaining to an older individual's ability to drive a car, manage finances, live independently, or follow a prescribed medical treatment. It is frequently assumed that standardized neuropsychological instruments provide specific, useful information regarding the older individual's ability to function in everyday life. Thus, it is generally acceptable practice to answer questions of functional competency or need for residential placement based on the results of traditional neuropsychological instruments (Dunn, Searight, Grisso, Margolis, & Gibbons, 1990). Some authors have even offered guidelines as to what everyday abilities may be tapped by specific neuropsychological tests (Chelune & Moehle, 1986). These guidelines are based on the presumption that individuals who evidence neuropsychological deficits on laboratory tasks will also demonstrate impairments in everyday activities that presumable require a similar set of abilities. However, the empirically validated relationship between commonly used neuropsychological measures and various activities of daily living remains to be adequately established.

The issue to which the above discussion addresses is that of ecological validity. One of the first psychologists to introduce the notion of ecological validity was Egon Brunswik in 1955, who used the term to refer to conditions under which generalizations may be made from the results of controlled systematic experiments to events occurring in the natural world (Hart & Hayden, 1986). Currently, ecological validity, as it pertains to the field of neuropsychological assessment, can be defined as "the functional and predictive relationship between the patient's performance on a set of neuropsychological tests and the patient's behavior in a variety of real-world settings (e.g. at home, work, school, community)" (Sbordone, 1996, p. 16).

Authors such as Chelune (1985) and Heinrichs (1990) have argued that central to the future success of neuropsychology will be its ability to yield useful and valid information regarding this issue. It remains to be seen whether instruments originally designed specifically to identify and localize brain dysfunction will also be found to be ecologically valid. Some researchers propose that new instruments must be developed specifically to assess real-world abilities (Wilson, 1993). However, Heinrichs (1990) suggests that an obvious starting place may be to begin by assessing the predictive power of extant instruments before creating new ones. The results of current and future research will thus determine whether neuropsychologist will have to incorporate into their battery of tests, new instruments that are designed specifically to predict everyday behaviors.

There have been several articles and book chapters published which review the now growing body of research being conducted on the relationship between neuropsychological test scores and everyday functioning (Heaton & Pendleton, 1981; Chelune and Moehle, 1986; Acker, 1986). The conclusions of these reviewers have generally been positive. Acker (1990) reports correlations between neuropsychological test data and functional measures have run as high as .85, although the explained variance is most often found to be around 40 percent. Unfortunately, this means that a large percentage of the variance in outcome is often left unexplained by neuropsychological measures. However, it was noted by such authors as Pendleton and Heaton (1981) that many previous studies used only one neuropsychological measure (frequently IQ scores) to attempt to predict functioning. More recently, researchers have been calling for a multivariate approach to neuropsychological assessment in the evaluation of ecological validity (Chelune & Moehle, 1986). These authors urge that instead of limiting the neuropsychological assessment to one or two tests, a full battery should be employed which measures a wide range of neuropsychological functions. In addition, it has further been suggested that other, non-cognitive variables, also be considered when attempting to predict daily functioning. For example, variables such as affective status, motivation,

personality, and level of family support should be considered when attempting to predict functional status (Wilson, 1993).

Measuring Functional Status

Before beginning a review of the literature pertaining to ecological validity, the issue of outcome measures needs to be addressed. Various types of outcome criteria have to be used in the study of the ecological validity of neuropsychological assessment. The particular outcome variable selected depends largely on the population with which one is studying.

Examples of outcome criteria that have been employed in past research include employment status, educational status, and activities of daily living. When studying a geriatric population, particularly one that is suffering from a dementing disease, this last class of outcome criteria seems to be most appropriate. The behaviors generally agreed upon as comprising activities of daily living (ADL) can be divided into two broad categories: 1) basic self-care tasks such as dressing, eating, and toileting and 2) higher-order living skills such as shopping, preparing food, managing finances, and using public transportation. This second group of skills is often referred to in the literature as "Instrumental Activities of Daily Living" (IADL) and are considered to involve more complex cognitive processes than basic self-care activities. The assessment of very basic ADL is most often used in patients with severely debilitating cognitive or physical deficits while the assessment of instrumental ADL are usually employed with mild to
moderately impaired elderly individuals. The current study will focus on the assessment of IADL's.

There has been little consensus as to the best way to operationalize and measure instrumental activities of daily living (Searight, Dunn, Grisso, Margolis, & Gibbons, 1989). Three methods of measuring ADL have been used in past research: functional status can be assessed using either self-report rating scales, caregiver-based rating scales, or performance-based measures of functional skills (Richardson, Nadler, Malloy, 1995). Each source of information has both benefits and limitations associated with it.

Some studies have attempted to utilize self-report data to measure functional and/or cognitive status. For example, research participants may be asked directly about their level of functioning through either a questionnaire or diary format. Although this may seem to be a straightforward approach to obtaining data on real-world functioning, it now appears that the reliability and validity of such measures are greatly affected by such variables as age, sex, and emotional status (Hart & Hayden, 1986). In addition, individuals with various types of brain dysfunction are likely to evidence impaired awareness of deficits. Several studies have documented discrepancies between self-reported impairments and informant-reported deficits as well as discrepancies between self-reported deficits and the results of neuropsychological tests (Sunderland, Harris, & Baddeley, 1983). Use of self report measures can be particularly problematic with the elderly. For example, the results of a study conducted by Sager and colleagues (1992) produced low rates of agreement between self-reported activities of daily living and performance-based measures in a sample of elderly hospitalized patients. Furthermore, poor agreement between measures was associated with cognitive impairment, suggesting that greater cognitive decline led to poorer agreement between measures. Similarly, Reisber, Gordon, McCarthy & Ferris (1985) reported that as AD progresses, patients consistently rate their memory impairment and emotional problems as less severe, whereas spousal ratings indicate greater impairment. In summary, it appears unwise to use patient self-ratings as criterion measures for ecological validity studies.

A second method of measuring activities of daily living is to have informants rate the patients' functional skills. Most often the rater is a family member who is closely involved in the care of the individual; however, if the patient is within a hospital or other inpatient setting, ratings may be made by a nurse or other staff member. This method was developed under the assumption that the rater will be familiar with the patient's level of functional abilities because they will have had opportunity to directly observe the patient in various real-life settings. Thus, one of the advantages of using caregiver ratings of functional status is that the rater has potentially observed the individual across multiple tasks and over a fairly long period of time. Additional advantages of this method include the ease and quickness with which information is collected, as well as the availability of the standardized assessment scales. Examples of a frequently used and well validated instruments of this kind include Lawton and Brody's (1969) Physical Self-maintenance Scale and Instrumental Activities of Daily Living Scale.

However, it should be noted that ratings made by caregivers cannot be assumed to always be completely accurate. Ratings made by family members or other care-givers may either underestimate or overestimate the patient's abilities for a number of different reasons. For example, the informant may lack extensive opportunity to observe the patient (Heaton & Pendlton, 1981; Richardson, Nadler, & Malloy, 1995).

In an attempt to side-step some of the above mentioned pitfalls, some researchers have attempted to measure behavior directly by observing the individual while they are in a standardized assessment situation that closely resembles relevant situations of everyday life. Some authors have suggested that these performance-based measures offer the most valid way of assessing daily living skills (Richardson et al, 1995). Specific behaviors that have been observed and rated within the older adult population include bathing, eating, medication management, utilization of the telephone, counting currency, and balancing a checkbook. A few scales have been developed to directly measure such behaviors.

However, many of the scales developed and reported in the research literature are not readily available, have not been widely used, or require the patient to be in an inpatient setting. Many of these instruments are also not well standardized and have not been demonstrated to be psychometrically sound (Franzen & Wilhelm, 1996). Lastly, several of the scales available assess only very basic activities of daily living (e.g., bathing and dressing) but neglect higher-level instrumental activities (e.g., taking care of financial matters). One scale to which most of the above mentioned criticisms do not apply is the Direct Assessment of Functional Status (DAFS) developed by Loewstein and colleagues (1989). This scale was developed specifically for the assessment of higher order daily living skills in patients with AD and related disorders. It is widely available, fairly extensively studied, and easy to administer in an outpatient setting.

It should be noted that even well developed observational measures of daily living skills present several disadvantages. There is the issue of reactivity to the situation, that is, the research participant may behave differently when they know they are being observed. In addition, such assessments offer more structure than in a real-world setting.

Studies of Ecological Validity in Geriatric Populations

The following section describes previous research examining the relationship between cognitive functioning and functional status in elderly individuals diagnosed with either dementia or other various psychiatric disorders. The review will be broken down into two sections. The first section will cover those studies which utilized rather brief measures of cognitive functioning to predict activities of daily living (e.g., mental status exams). The second part of the literature review will discuss studies that have employed more extensive neuropsychological batteries to predict functional status. Due to the numerous problems in utilizing self-report measures of functional status (as discussed in previous sections), only studies employing either performance-based measures of functional capacity or caregiver/informant-based ratings will be reviewed. Studies which utilized self-report measures of functional status were not included in this review due to the problems inherent in this methodology (see above discussion).

Predicting Functional Status Based on Brief Measures of Cognitive Functioning

Reed, Jagust & Seab (1989) examined the relationship between scores on the Mini Mental Status Exam (MMSE) and primary care-giver reported ADL's Lawton's (1969) Physical and Instrumental Activities of Daily Living Scales. Subjects included 59 patients diagnosed with some form of dementia. Results indicate that MMSE scores explained slightly over one-third of the variance in physical and instrumental ADL ratings in the entire sample. However, when subjects were divided into groups of mild and moderate-severe dementia, MMSE was significantly associated with both physical and instrumental ADLs only in the moderate-to-severe group. These findings suggest that MMSE scores predict a moderate amount of variance in ADLs for moderate-severely demented patients but cannot be used to estimate functional status in only mildly demented individuals.

Pearson, Teri, Reifler, & Raskin (1989) studied the relationship between MMSE and functional status in groups of clinically depressed and non-depressed Alzheimer patients. Specifically, this group of researchers investigated whether a diagnosis of depression impacted patients' ability to carry out activities of daily living, beyond the effects of cognitive impairment as measured by the MMSE. Participants in the study included a total of 50 individuals diagnosed with dementia of the Alzheimer's type: 20 of whom had concomitant with major depression, 30 AD patients without depression. Functional status was obtained through family member ratings of the patients' abilities to use the telephone, get to places beyond walking distance, shop for food or cloths, prepare meals, do housework, take medication appropriately, and manage money. Significant positive associations were obtained between the MMSE and all functional items except meal preparation. Correlation coefficients ranged from .24 to .45 and thus MMSE scores generally account for a fairly modest amount of the total variance in functional status. Additionally, when cognitive status was controlled for, a diagnosis of depression was found to have a further detrimental effect on functional status.

Freels and colleagues (1992) conducted a study to determine the independent association between cognitive impairments (as measured by the MMSE), medical problems, psychological/behavioral symptoms and functional status. Subjects included 240 individuals diagnosed with probable Alzheimer's Disease. Ratings of functional status were made by a psychiatrist in six areas of functioning including: dressing, bathing, eating, walking, transferring, and toileting. Apparently, these ratings were made on the basis of a psychiatric interview but this information is not made clear. Fifty-eight percent of the sample was found to be impaired in one or more ADL. MMSE scores were found to be independently associated with ADL impairment. Furthermore, some emotional/behavioral conditions accounted for additional variance in functional status. Specifically, behavioral disorders (e.g., screaming, wandering, aggressiveness) and apathy were independently associated with ADL impairment. This study did not confirm other research (Pearson, Teri, Reifler, & Raskin; 1989) suggesting that depressive mood is independently associated with functional impairment.

Vitaliano, Breen, Albert, Russo, and Prinz (1984) designed a study to determine if portions of the Mattis Dementia Rating Scale (MDRS; Mattis, 1976) and the MMSE, could be used to predict daily functioning status in a group 34 individuals with Alzheimer's dementia. The MDRS is a widely used instrument used to screen for dementia, and in its entirety consists of five subscales each measuring a different cognitive domain. In this study, the attention and memory items from both the MMSE and MDRS were selected out and grouped into five cognitive classes: attention, calculation, recognition memory, recall, and orientation. The Record of Independent Living (Weintraub, Baratz & Mesulam; 1982) was used to rate functional competence, which assesses three broad areas including maintenance (e.g., feeding, dressing), communication (talking and listening), and recreation (reading, writing, and hobbies). Ratings were made by a participant's family member. Five hierarchical regressions were performed with each of the five cognitive classes predicting the three behavioral variables. Within each analysis the association of the set of variables in a cognitive class was first examined with recreation, then with communication (with recreation removed) and lastly with maintenance (with both recreation and communication removed). Recreation was examined first because it was thought to represent the highest level of functioning in this population. Results reveal that recreation was significantly associated with attention, recognition, calculation, and orientation. After recreation was parceled out, no significant associations were found between cognitive variables and communication. However, with the variance from both recreation and communication removed, significant associations were found between maintenance (e.g., feeding and dressing) and attention and recognition. The authors of this study conclude that it is possible to predict a significant degree of functional competence in a group of AD patients based on knowledge of their attention and memory impairments.

Nadler, Richardson, Malloy, Marran & Brinson (1993) utilized the entire MDRS to predict daily functioning. Unlike Vitaliano et al. (1984), these researchers employed a performance based measure of functional status, as opposed to using care-giver ratings of daily functioning. The Occupational Therapy Evaluation of Performance and Support (OTEPS) scale was used to assesses the elderly individual's ability to perform daily living tasks. Specific areas of functioning assessed by this scale include: hygiene, safety, medication administration, cooking and nutrition, money management, and community access and utilization. This instrument was administered by an occupational therapist within an inpatient psychiatric setting. The participants in this study included 50 elderly individuals, many of whom were suspected of being demented. The results of linear regression analyses revealed that the MDRS total score significantly predicted all of functional abilities except cooking. Standard multiple regression analyses using the MDRS subtests as predictors again revealed that all OTEPS functional domains except for cooking were significantly predicted. Variance in functional status accounted for by the MDRS ranged from 32% for hygiene/self care to 49% for safety. Examination of individual beta weights revealed a significant contribution of the Initiation/Perseveration subtest of the MDRS for all functional domains, except hygiene. Analysis of Pearson correlation coefficients also revealed significant relationships between the Initiation/Perseveration subscale and all functional domains except cooking. The MDRS Memory subtest was also significantly correlated with each functional domain except cooking and money management. The other MDRS subtests (Construction, Abstraction, and Attention) were not significantly correlated with any of the functional domains. The authors of this study concluded that there is a moderate association between cognitive abilities and performance based assessment of both instrumental and basic self-care activities within a psychogeriatric population. In particular, functional status was most associated with executive functioning and memory.

The above mentioned studies generally provide support for the association between global cognitive decline and decrease functional status in some geriatric populations. However, investigations utilizing the MMSE alone suggest that only a fairly modest amount of variance in functional status can be accounted for by scores on a mental status exam. It should be noted that, brief cognitive screens such as the MMSE have been shown to have limited use as neuropsychological assessment tools. For example, studies on the MMSE have demonstrated a high false negatives rate in detecting mild cognitive impairment because such screening instruments allow only a cursory evaluation of various cognitive domains (Tombaugh & McIntyre, 1992). The two studies which employed the MDRS as a measure of cognitive functioning, suggest that this instrument may be a somewhat better predictor of daily functioning than the MMSE. This is not surprising considering the MDRS, although still considered a brief assessment instrument (Lezak, 1995), offers a much more comprehensive evaluation than the MMSE. Results of the research with the MDRS tentatively suggests that cognitive domains such as memory, attention and executive functioning may be most predictive of functional status.

Predicting Functional Status Based on a Battery of Neuropsychological Tests

As a result of the limitations in using brief measures of neuropsychological functioning, several investigators have recently begun to use more extensive and comprehensive neuropsychological batteries in an effort to predict the daily functioning of older individuals.

Breen and colleagues (1984) investigated the relationship between cognitive abilities and functional competence in basic living skills in a group of AD patients. Participants in the study consisted of 35 community residing elderly individuals diagnosed with AD; half of the sample was also diagnosed with Major Depression in addition to AD. Measures of cognitive functioning included the MMSE, Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955), and the Wechsler Memory Scale (WMS; Wechsler, 1945). Functional competence was assessed using a care-giver completed version of the Blessed Dementia Rating Scale (BDRS; Blessed & Tomlinson, 1968) and assessed such activities of daily living as basic self-maintenance skills and the ability to perform various household chores. Significant associations were found among the various cognitive measures and functional status in both groups, but the pattern of such relationship differed by group. Within the nondepressed group, all correlations between cognitive measures and functional competence were significant: Verbal IQ ($r = -.56$), Performance IQ ($r=-.61$), Full Scale IQ ($r=-.75$), WMS Quotient ($r=-.63$), MMSE ($r=-.75$). The pattern of correlations in the depressed group of AD patients was somewhat different, significant associations were found between functional status and MMSE (r=-.66) and WMS memory quotient (r=-.83). The mean shared variance between the cognitive measures and functional status was 41% for the nondepressed group and 37% for the depressed group. Thus, although the overall amount of variance shared is similar in each groups, different tests were responsible for the relationship with BDRS. Intellectual measures accounted for the greatest proportion of variance in functional status in the nondepressed AD patients, while memory measures accounted for the greatest portion of variance in the depressed AD group.

Goldstein, McCue, Rogers and Nussbaum (1992) investigated the ability of various memory measures to predict daily functioning in a sample of elderly adults. Participants in the study were comprised of three groups including individuals with Major Depression, probable Alzheimer's Disease, and healthy controls. Memory measures utilized in the study included the Rivermead Behavioral Memory Test, the Wechsler Memory Scale, and the Memory scale from the Luria-Nebraska Neuropsychological Battery. Functional status was measured through the administration of portions of a performance-based measure called the Performance Assessment of Self-Care Skills (PASS) (Rogers, 1984). Two subscales of the PASS were used in this study: the Physically Orientated Instrumental Self Care subscale and the Cognitively Orientated Self Care subscale. Specific skills measured included the ability to wash dishes, make a bed, wash clothing, use a vacuum cleaner, operate a telephone, sew on a button, shop, write a check and balance a checkbook, cook pudding, prepare a letter, demonstrate medication management, and verbalize appropriate response to danger. All items were scored on a five-point scale and then summed together to get a composite score. All patients were administered the neuropsychological memory measures while they were on an inpatient geriatric unit. Subsequent to discharge the patients were administered the PASS in their place of residence at two-week and six-month follow up. Pearson r correlations were obtained between the three memory measures and the PASS scores obtained two weeks and six months after discharge. For the overall sample, which included all three patient populations, all correlations were highly statistically significant in the expected direction. However, when analyzing each diagnostic group separately, tests of memory were found to correlate highly with self-care skills among depressed and normal controls but not among dementia patients. Findings from this study suggest that specific and unique neuropsychological instruments may need to be used to accurately predict functioning in different patient populations. However, this study did have a number of limitations. First, the overall sample size was small; additionally, the findings may have been influenced by the fact that the dementia group had the fewest number of participants. Lastly, due to the small sample size the investigators were limited to the use of simple correlations and were unable to conduct multivariate analyses.

Searight and colleagues (1989) employed a popular standardized neuropsychological battery, the Halstead-Reitan (HR) to predict daily functioning in a geriatric population. Participants in this study consisted of 40 geriatric patients suspected of dementia; eleven of the participants were outpatients and 29 were on acute inpatient geriatric-psychiatric or general psychiatric hospital units. Five tests from the Halstead battery were used to yield seven predictor variables, these included: number of errors on the Category Test, number of errors on the Seashore Rhythm Test, number of errors on the Speech Sounds Perception Test, the average number of finger taps per ten second interval for the dominate hand, and

Tactile Performance Test - total time, location and memory. The Scale of Competence in Independent Living Skills (SCILS) was used to measure care-givers' ratings of the patients' daily living skills. Dimensions assessed included personal hygiene, money management, cooking, and communication by phone. A canonical correlation between all of the SCILS and all Halstead Reitan variables was quite high, suggesting that 82% of the variance in functional status may be accounted for by the neuropsychological variables. However, when utilizing multiple regression and Pearson correlation coefficients the relationship appeared more modest suggesting that from 33 to 45 percent of the variance in the SCILS was accounted for by the HR variables. When the SCILS 'Total Score' was examined in relation to the individual subtests of the HR, Speech Sounds, Seashore Rhythm, Tactile Performance-Memory, and Tapping-Dominate Hand demonstrated the strongest overall relation. Interestingly, there was only a small correlation between the Category test and the functional variables which the authors attribute to a floor effects when using this particular measure in a dementia population.

Dunn, Searight, Grisso, Margolis, and Gibbons (1990) also published another research article using the same subject population as in the above mentioned study (Searight et al, 1989). However, this time they utilized a performance based measure of daily functioning rather than care-giver ratings of functional status. The Community Competence Scale (CCS) was the instrument used to assess functional status; it is comprised of 10 subscales including Emergencies, Acquire Money, Compensate for Incapacitates, Manage Money, Communication, Care of Medical Needs, Proper Diet, Personal Hygiene, Maintain Household, and Utilize Transportation. The scores obtained on the individual subscales, as well as the total summated score, were used in data analysis. The same seven variables from the Halstead-Reitan Battery as noted above were again uses here. Results of a canonical analysis revealed that the HR scores predicted 68% of the variance in the CCS subscales. Again, statistical analysis using multiple regression yield more modest estimates of explained variance. The authors conclude that there appears to be a moderately strong overall relationship between neuropsychological functioning as measured by the HR and functional daily living skills as measured by the CCS. The specific HR tests that were most consistently found to be associated with functional status were Speech Sounds Perception, Seashore Rhythm, and Tactile-Memory Performance. It is interesting to note that when comparing the findings of this study and the above mentioned study, similar results were found using either an informant-rated scale of functional status or behavioral ratings. Additionally, the findings of both these studies suggest that attention and memory are likely to be cognitive domains that play important roles in the daily functioning of individuals with suspected dementia.

One of the criticisms of the above mentioned study is its use of the Halstead Reitan battery with an elderly demented population. The length of this battery makes it impractical to administer to this population as they tend to fatigue easily (Nadler et al, 1989). Alternatively, McCue, Rogers, and Goldstein (1990) used a shortened version of the Luria Nebraska (LNNB-S), a battery that was designed specifically for use with older adults. Subjects in this study included 58 elderly individuals on a geropsychiatric unit of an acute psychiatric hospital. Half of the sample was diagnosed with dementia whereas the other half of the sample was diagnosed with a psychiatric disorder. The functional assessment utilized the Performance Assessment of Self-Care Skills (PASS; Rogers, 1984). Items of this scale are classified into four groups: Personal Self Care (i.e. feeding, grooming), Mobility (i.e. transfer in and out of chair, lifting an object), Physically Oriented Instrumental Self-Care (i.e., wash dishes, make bed), and Cognitively Orientated Instrumental Self-Care (i.e., use telephone to obtain information, sew on a button, balance a checkbook). The PASS was administered by a registered occupational therapist. Relationships between the LNNB-S scales and performance of everyday functions were examined through use of multiple regression procedures and univariate correlational methods. The neuropsychological instrument significantly predicted scores on the Physical and Cognitively Oriented Instrumental Self-care subscales, but not on Personal Self-care or Mobility subscales. Specifically, the Memory and Motor scales of the LNNB-S accounted for 45% of the variance in the cognitively oriented aspects of instrumental care. These results are interpreted by the authors as suggesting that neuropsychological test performance is more predictive of activities of daily living that have a strong cognitive component as compared to those activities which are primarily dependent on simple self-care and/or basic physical ability. One of the limitations of this study, however, was the fact that functional skills were classified into categories according to the nature of the task and thus it was not possible to analyze the relationship between specific functional tasks and neuropsychological functioning.

Loewenstein, Rubert, Arguelle, and Duara (1995) have examined the relationship between a mixed battery of neuropsychological tests and functional capacities in Spanish and English-speaking individuals with dementia. All participants in the study had been diagnosed with possible or probable Alzheimer's dementia according to NINCDS-ADRDA criteria. Neuropsychological instruments used in this study included: MMSE, Fuld Object Memory (Fuld, 1977), Logical Memory and Visual Reproduction (immediate recall) from the WMS, Boston Naming Test (Kaplan, Goodglass & Weintraub, 1983), FAS Controlled Word Association Test, Block Design, Object Assembly, Similarities, and Digit Span from the WAIS-R. The instrument used to measure daily living skills was the Direct Assessment of Functional Status (DAFS), developed by the first author and his colleagues. This is a performance-based instrument which requires the patient to complete in several functional tasks including reading a clock, dialing a telephone, preparing a letter to mail, counting currency, writing a check, balancing a checkbook, and shopping with a written list. Stepwise multiple regression was used to determine which neuropsychological variables best accounted for the variance in each area of daily functioning. For the English-speaking group telling time was most associated with Digit Span and Object Assembly, utilizing the telephone was best predicted by Block Design; preparing a letter was best predicted by verbal fluency, Fuld memory retrieval and Object Assembly; counting currency was most associated with Digit Span, and Fuld Retrieval; writing a check was associated with verbal fluency, Fuld Retrieval; balancing a checkbook was associated with Digit Span, Visual Reproductions, Fuld Retrieval, and Object Assembly; and shopping was associated with Boston Naming and Block Design. The pattern of results were somewhat different in the Spanish speaking group. Block Design, Digit Span, MMSE and FAS were found to be the strongest neuropsychological predictors for the entire sample. However, it should be noted that the majority of functional measures had multiple neuropsychological predictors, suggesting that unique combinations of different cognitive abilities appear to be associated with particular functional tasks.

The last study to be mentioned was conducted by Richardson, Nadler, & Malloy (1995). These researchers also sought to predict performance-based daily functioning in an elderly neuropsychiatric population using a mixed battery of neuropsychological tests. Participants in the study included 108 older adults who were on an inpatient psychiatric unit; diagnoses included suspected dementia as well as other psychiatric disorders. Neuropsychological measured used included the Boston Naming Test, Hooper Visual Organization Test, COWAT, and immediate recall of the Logical Memory and Visual reproduction subtests of the WMS-R. Activities of daily living were measured by the OTEPS (described earlier). The canonical correlation revealed that 43% of the variance in ADL performance was accounted for by neuropsychological variables. Results of a multiple regression analyses were significant for 4 out of 5 of the areas assessed on the functional measure, with the battery of neuropsychological tests accounting for 14% to 32% of the variance in ADL performance. Specifically, the Hooper was the best individual predictor of functional dependence across each AD domain, followed by performance on the memory measures.

The results of the above mentioned studies suggest that a moderate correlation exists between neuropsychological measures and everyday functioning in a geropsychiatric population. There is quite a bit of variability in the specific neuropsychological tests used which makes it difficult to draw conclusions regarding which specific measures are best at predicting daily functioning. General cognitive domains that have most consistently been found to relate to functional status include attention, memory, and executive functioning. In addition, results suggest that neuropsychological measures may best predict activities of daily living with a strong cognitive component rather than more elementary self-maintenance activities. The scales used to assess daily functional status have varied among studies and have included both performance-based instruments and informant-based ratings; for the most part, results using these two methods appear to be yielding similar results. Unfortunately, the populations of subjects studied have often included a heterogeneous group of both neurological and psychiatric patients. As several past researchers have pointed out, the correlation between neuropsychological measures and ADLs often differ among various patient groups. Thus, it is particularly difficult to draw conclusion specific to AD patients.

The Present Study

The results of recent investigations have been encouraging as research has begun to yield empirical support for the idea that neuropsychological functioning is significantly associated with the ability to carry out various activities of daily living. However, further research is needed to determine the extent to which deficits in specific neuropsychological abilities lead to impairments in particular functional domains. The present study was designed to extend and replicate the findings of previous research in several ways. As originally recommended by Heaton and Pendleton (1981), a comprehensive battery of neuropsychological measures was utilized, the goal of which was to tap multiple cognitive domains. An effort was made to select neuropsychological tests which are widely available and commonly employed in the assessment of the Alzheimer's patient population. In order to get a comprehensive sampling of functional status, both performance-based ratings and caregiver/informant-based ratings of activities of daily functioning were included. Information on mood and various demographic data were also obtained in order to assess the contribution of these variables in predicting functional status. A rather homogeneous diagnostic subject group was utilized; only individuals diagnosed with either Probable or Possible dementia of the Alzheimer's type were included as participants in this study. In summary, the purpose of the present study was to provide a detailed analysis of the relationship between a comprehensive neuropsychological battery of tests and functional status in a group of well diagnosed AD patients. Based on previous research it was expected that there would be at least a moderate overall correlation between neuropsychological functioning and daily living skills. This study further sought to determine which particular neuropsychological instruments are most strongly associated with each specific functional domain.

Method

Participants

Participants in the current study included 42 individuals (9 males and 33 females) receiving outpatient treatment through a memory disorders clinic at a county hospital. Twenty-seven participants were white and 15 were African American. All participants were diagnosed with either Possible or Probable dementia of the Alzheimer Type according to the NINCDS-ADRDA criteria. Individuals were within the mild to moderate ranges of dementia severity as determined by their score on the MMSE. According to care-giver reports, the average length of time participants in this study had been evidencing some signs of cognitive decline prior to coming into the memory clinic was 27.69 months (SD = 17.68). One third of the sample reported a family history of Alzheimer's disease. The mean age of the participants in this study was 71.67 (SD = 8.52). The average years of education for the sample was 10.14 (SD = 2.75). Due to the verbal requirements of several of the neuropsychological tests included in the study, only individuals whose primary language was English were included. Many patients had age-related medical disorders including arthritic conditions, mildly impaired sensory functioning and cardiovascular disorders. However, in accordance with the NINCDS-ADRDA recommendations, all patients underwent neuroimaging (either CT or MRI) in order to rule out vascular dementia or other neurologic disorders. No subjects was included in this study whose cognitive impairment were thought to be due primarily to a systemic illness, specific neurological syndrome, or other identifiable cause of brain dysfunction other than AD. The subject pool in this study included persons who were going to receive treatment with Aricept (Donepezil), a psychopharmacological therapy for treatment of Alzheimer's symptoms. However, in all cases, neuropsychological and functional testing was completed prior to the inception of pharmacological treatment.

Apparatus

Consent Form. A consent form was developed for this study (see Appendix B) which all participants were asked to read and sign. All contents of this form were verbally explained, as well, to ensure that participants understand the information. The font size of the print on the consent form was enlarged to ensure that the participants can read it easily. For those subjects who were quite cognitively impaired, consent was also sought from a caregiver.

Background and Demographic Form. This instrument was developed by the current researcher in order to collect basic demographic and background information (see Appendix

C). It was completed by the researcher based on information gathered from the patient's medical file, as well as reports from the primary caregiver(s). Specific information collected included the participant's age, gender, race/ethnicity, current MMSE score, occupational history, current living arrangements, duration of symptoms,
past and current medical conditions, history of psychiatric illness, current medications, and family history of AD.

Geriatric Depression Scale (Brink et al., 1982). This is a 30-item self-report questionnaire assessing the emotional symptoms of depression (e.g., unhappiness, dissatisfaction with life, feelings of worthlessness, etc.). No somatic symptoms associated with depression are included in this measure. Each question is answered either yes or no; the directionality of the answers score for depression change randomly. Internal consistency is reported at .94 (Brink et al., 1982) while retest reliability after one week was .85 (Koenig et al., 1988). Criterion validity was measured against the Research Diagnostic Criteria and reported as .82 (Yesavage, et al., 1983).

The instruments used to assess neuropsychological functioning will be as follows:

California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987). This instrument assesses verbal learning and memory. A list of 16 words (shopping items) is read out loud to the participant over the course of 5 trials. Immediate recall is recorded after each trial. The participant is then presented with a list of distractor words and immediate recall of the distractor items recorded. Following this list, the participant will be asked to freely recall the words from the initial list, and then is provided with semantic cues and asked to recall the initial list of items. After a 20 minute delay, the patient is again asked to recall the list without semantic cues, with semantic cues, and to recognize the items embedded within a list of distractor items. Split-half reliability correlation coefficients of .77 to .86 have been reported (Delis, Kramer, Fridlund, & Kaplan, 1990). Correlations with other memory tests such as the Wechsler Memory Scale are reported to be adequate (Delis, Kramer, Kaplan, & Ober, 1987; Schear & Craft, 1989). Specific score profiles have been empirically established for various dementing diseases including Alzheimer's Disease (Delis, Massman, Butters, Salmon, Cermak, & Kramer, 1991). Additionally, the CVLT has been found to aid in the discrimination of AD and depression (Massman, Delis, Butters, Dupont, & Gillin, 1992).

Wechsler Memory Scale (WMS; Wechsler, 1945) contains seven subtests, the scores of which are summed together to yield a total score, expressed as a Memory Quotient (MQ). Abilities measured include immediate learning and recall, attention/concentration, and orientation (Lezak, 1995). The individual subtests which comprise the entire scale include: Personal and Current Information, Orientation, Mental Control, Logical Memory, Digit Span, Visual Reproduction, and Associate Learning. For the current study, scores from two of the individual subtests will be utilized, in addition to the MIQ; these include Digit Span and Logical Memory. Digits Span consists of both Forward and Backwards spans were used and require the participant to repeat back increasingly long strings of numbers both forwards and in reverse order. The scores for these two tests are combined to yield a total score. This test is commonly used as a measure of attentional capacity and immediate verbal recall. Digit span is reported to hold up well among the healthy aging. Individuals with mild dementia may also evidence normal performance on this test; however as the disease progresses beyond the early stages of dementia performance declines significantly (Lezak, 1995). Secondly, the Logical Memory subtest requires participants to repeat back as much as possible about two short stories they have been read. For the purposes of the current study, a delayed recall of this test was also utilized in which the patient again recounted information about the stories after a 30-minute delay. Logical Memory has been found useful in identifying dementia and in tracking its progression (Storandt, Botwinick, & Danziger, 1986).

Trail Making Parts A & B. This test was originally part of the Army Individual Test Battery and was later incorporated into the Halstead Reitan Neuropsychological Battery (Reitan & Wolfson, 1993). The test consists of two parts, Part A and B. Subjects must first draw lines to connect consecutively numbered circles (Part A). Next, the subject must connect consecutive numbered and lettered circles by alternating between the two sequences (Part B). The subject is urged to connect the circles as quickly as possible without lifting their pencil from the paper. The examiner is required to correct the subject when mistakes are made and the score is based on the total time until completion of the task. Abilities measured by this test include psychomotor speed, visual scanning, attention, and concept formation. It is highly vulnerable to the effects of brain injury (Lezak, 1995). In addition, both parts A and B have been found to be very sensitive to the progressive cognitive decline of dementia (Greenlief, Margolis, & Erker, 1985). A time constraint of four minutes was set for Trails B; that is, the test was discontinued if the patient was not near completion of the task after working on it for four minutes. Thus, in addition, to the typically time scores, and additional variable, whether or not the patient was able to complete Trials B (1=yes, 2=no), was also calculated.

Rey-Osteirreth Complex Figure Test. This is a test of perceptual organization and nonverbal memory. The participant first is asked to copy a complex line drawing. After a 20 minute delay, the participant will be asked to reproduce the drawing from memory. Scoring criteria are provided to enable reliable scoring of both the direct copy and recall portions of the test. Inter-rater reliability as been found to be rather high, generally around .95 (Lezak, 1995). There are a total of 18 units which are scored on an 0 to 2 point scale. Higher scores indicate better performance. The delayed recall portion of this test will be used as a measure of nonverbal long-term memory.

Benton Visual Retention Test (BVRT; Sivan, 1992). This test will be used as a measure of short-term nonverbal memory. The participant is presented with 10 stimulus cards each with various geometric shapes on them. Each card is exposed for a period of 10 seconds. Immediately after presentation of each card, the patient is asked to reproduce the figures from memory. Both the number of correct designs and the number of errors are scored. The manual furnishes adult normals which are based on age and estimated premorbid IQ. Interrater reliability for the number of correct designs ranges from .96 -.85 and .97 - .93 for error scores. Test-retest reliability has also been found to be adequate by several investigators (Lezak, 1995). Research on the BVRT has shown that it is sensitive to cognitive decline associated with the early stages of Alzheimer's disease. The number of correct responses significant discriminated dementia patients from normal control subjects (Botwinick, Storandt, & Berg, 1986) and the error score has been found useful in differentiating depression from dementia (La Rue, D'Elia, & Clarke, 1986). This test will be used as a measure of immediate memory for nonverbal information.

Controlled Oral Word Association Test (COWAT; Benton & Hamsher, 1976). The COWAT will be used as a measure of verbal fluency and semantic memory. The participant is asked to generate as many words as they can that begin with letters F, A, and S in one minute time periods. Means and standard deviations for older age groups (ages 50-54 to 75+) stratified by education are provided by Spreen and Strauss (1991). Means are reported to remain relatively stable with age, although for those individuals with lower education levels, scores tend to decline mildly in old age. Test-retest reliability has been found to be around .70 for elderly individuals tested one year later. Frontal lobe lesion, regardless of the side have been found to depress verbal fluency. Additionally, reduced verbal fluency has been associated with every dementing process, although the underlying defect tends to vary (Lezak, 1995).

Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983). This test consists of 60 line drawings of items ranging in familiarity from common or uncommon. If the participant is unable to name the object in the first try they are provided a semantic cue. If the subject is still unable to name the object, they are given a phonemic cue. This instrument is used to measure the degree of word-finding difficulty an individual shows. No appreciable age-related declines in performance occur on this test until the late 70s when the drop is only slight (Lezak, 1995). The BNT is widely used in the assessment of

dementia and is considered a sensitive indicator of both the presence and degree of deterioration (Storandt, Botwinick, & Danziger, 1986).

Apraxia Test. This test is taken from the Western Aphasia Battery (Kertesz, 1982) and is intended to assess ideomotor and ideational apraxia. Initially the participant is asked to pantomime the use of a variety of objects. If the subject has difficulty in pantomiming the object, the examiner demonstrates the series of movements and ask the participant to copy the movements. If the participant is still unable to successfully mimic the movements, they may demonstrate the appropriate movements while actually using the object. Full credit is given for independently providing the appropriate pantomime. Partial credit is given for pantomiming correctly after demonstration by the examiner or by using the object to perform the sequence of movements.

Similarities. This test is taken from the Wechsler Adult Intelligence Test - Revised (Wechsler, 1981). In this test of verbal concept formation the subject must describe what each pair of words has in common. The word pairs range in difficulty from easy (“orange-banana”) to more difficult (“fly-tree”). Each item is scored from 0 to 2 depending on the abstract quality of the response. This test has been found to be sensitive to the effects of brain damage in general and has been reported to be vulnerable to the effects of dementia in particular (Lezak, 1995). Relatively large losses on this test have been found to be among the earliest predictors of abnormal cognitive change in middle-aged persons (La Rue & Jarvik, 1987).

The assessment of functional status utilized both performance-based measures of activities of daily living as well as an informant-based measure. The performance-based assessment procedure used in the current study employed the Direct Assessment of

Functional Status (DAFS: Loewenstein et al., 1989). Two additional tasks were added on to the DAFS in order to obtain a more comprehensive assessment. These additional tasks include a modified version of the Misplace Objects Test (Crook, Ferris, & McCarthy, 1979; West, 1986) and a map following task (the Test of Spatial Orientation; Semmes, Weinstein, Ghent, & Teuber, 1955). It should be noted that when reporting and discussing the results of this study, the misplaced objects task and the map following task will be considered part of the DAFS. The Instrumental Activities of Daily Living Scale (IADL; Lawton & Brody, 1969) was utilized as an informant-based measure of functional capacity. Higher scores on all performance-based functional tasks indicate better performance, while high scores on the informant-based measure are indicative of poor performance. All functional measures are described in detail below:

Direct Assessment of Functional Status (DAFS: Loewenstein et al., 1989). This scale was developed specifically to provide a behaviorally based measure of daily living skills in persons with Alzheimer's dementia and related disorders. The DAFS, as it was originally developed, assessed seven functional domains and thus is divided into the following subscales: Time Orientation, Communication Abilities, Transportation, Financial Skills, Shopping Skills, Eating Skills, and Dressing/Grooming. Each of the domains tapped by this instrument had been previously identified in the literature as an important areas in the assessment of older individuals. Within each domain there are various tasks which the elderly individual is asked to complete and upon which behavior is observed and rated. Inter-rater reliability have been found to be quite good with at least 85% agreement between raters on each item of the scale. Test-retest reliability coefficients have been found to range from .55 to .91 for the various subscales. Normative data for both elderly controls and AD patients are available. Several validity studies have also been conducted on this instrument. The DAFS was found to be significantly correlated with the Blessed Dementia Rating Scale, a well known scale used to assess functional status based on care-giver reports. Specifically, the correlation between this established measure of functional status and the DAFS was -.66 in a group of AD patients. In a study comparing DAFS scores for individuals with AD, depression or age-matched controls, no differences were found between groups with respect to age or education. There were also no significant differences found between the depressed group and controls with regard to the functional variables. However, AD patients scored significantly lower on all functional items except telling time, identifying change, eating, and dressing/grooming skills. These findings suggest that AD patients with mild to moderate dementia exhibit considerable impairment across several functional domains relative to both normal or depressed controls.

The authors of this scale have recommended and used a modified version of the original DAFS for the assessment of mild to moderately impaired Alzheimer's patients (Loewenstein, et al., 1992; Loewenstein, et al., 1995). This was the version of the DAFS used in the current study. In this revised edition of the DAFS rudimentary functional tasks such as identifying currency, eating, and dressing/grooming have been excluded. A description of each of the functional tasks assessed by the modified version of the DAFS is as follows:

1. Reading a Clock: Participants are asked to tell time at each of four progressively more difficult clock settings using an analog clock.

2. Telephone Skills: The participant is presented with a push-button telephone and asked to dial the operator, to dial a single number presented orally, to dial a single number from written form, and to dial the number of a specific person from a list of names and numbers.

3. Preparing a letter for mailing: After being provided with all the necessary materials the participant is required to address an envelope (by copying a specific written name and address provided by the examiner), write a correct return address on the envelope, place a stamp on the envelope, fold the letter, insert the letter into the envelope, and seal the envelope.

4. Counting currency: The participant is asked to count change and paper currency over four trials of increasing difficulty.

5. Writing a check: Participants are asked to make out a check to a specified party (a fictional grocery store); they are given points for writing the correct numeric and written amounts, entering the date, and providing a signature.

6. Balancing a checkbook: Participants are required to balance a checkbook at increasing levels of difficulty. These are simple subtraction problems presented in checkbook ledger format.

7. Shopping with a written list: Participants are asked to select 4 grocery items out of a group of 20 using a written list.

Two additional tasks will be added to the performance-based functional assessment:

Misplaced Objects Test. A modified version of the original Misplaced-Objects Task

(Crook, Ferris, & McCarthy, 1979; West, 1986) was administered. Originally the test consisted of presenting the participant with a 16x20-inch board on which the cross-section of a furnished seven-room house is depicted along with 10 magnetized vinyl shapes representing objects frequently misplaced in the home. The specific objects used include keys, eyeglasses, gloves, a pen, book, ring, umbrella, watch, billfold, and cigarette lighter. The participant is asked to place the objects in various places throughout the house. The objects are then removed and the board put out of sight. After a time delay the participant is again presented with the board and objects and asked to replace each object in the room previously chosen. The test-retest correlation is reported to be .84. Highly significant differences were found between elderly individuals with a memory impairment and young normals. There was also a significant difference between the performance of the impaired elderly group and a group of unimpaired age-matched controls. West (1989, as sited in Larrabee and Crook, 1996) used a modified version of the Misplaced-Object task as part of the Everyday Memory Interview (EMI). Here the subject is given 10 real objects to place around the testing room. Half of the objects can be placed in plain view while the other half must be hidden from direct view. The subject is later asked to find the objects. The current study will thus utilized West's modified version of the original Misplaced-Objects Task. A 30 minute delay will be used between initial placement of the objects and recall of their location. Scores range from 0 to 2 for each of the ten items. Participants received a score of 2 if they correctly recall the item and are able to locate it. A score of 1 was obtained if the participant needs to be reminded of the object for which they are looking, but then correctly locates the object. Participants received a zero if, after cueing, they are still unable to recall where the object was placed.

Test of Spatial Orientation. A modified version of the original Test of Spatial Orientation (Semmes, Weinstein, Ghent, & Teuber, 1955) was also administered as a measure of the participants' ability to follow a map. The test requires the individual to follow a particular route around a room based on the representation of that route presented on a hand-held map. The direction "North" is drawn on the top of the map and the subject is informed which is the north wall of the testing room. Research has suggested that this test is particularly sensitive to parietal lobe dysfunction as individuals with injuries to this area of the brain showed the most impairment on this test (Semmes, Weinstein, Ghent, & Teuber, 1963). Although the original version of this test required the subject to complete five different maps, for practical reasons, in the current study participants completed only one of the five original routes. The route used in this study requires the patient to walk to eight specific locations. For each correctly reached location the patient received one point, thus, scores on this test can range from 0 to 8. If the patient made a wrong turn and goes to an incorrect location, the error was corrected and they were shown the location where they should have gone. This turn was scored as a zero and the patient continued the test from the new location.

Instrumental Activities of Daily Living Scale (IADL; Lawton & Brody, 1969). This is a widely used scale which was developed to assess complex self-maintenance skills in older adults. It was designed to be completed by caregiver such as a family member or nursing home/hospital staff member. Areas assessed by this scale included the ability to use a telephone, shop, prepare food, do housework, laundry, utilize public transportation, medication administration, and ability to handle financial responsibilities. In the current study one caregiver for each participant was asked to complete this questionnaire. Inter-rater reliability is reported to be .85 for the total IADL score.

Procedure

The neuropsychological test data was collected over the course of two sessions. During the initial session, each participant received a neuropsychological screening evaluation for diagnostic purposes. This session took approximately 1 to 1 ½ hours to complete; tests given during this session included: Rey-Osterreith Complex Figure Test (direct copy and delayed recall portions), CVLT (immediate and delayed trials), Geriatric Depression Scale, Trail Making Parts A & B, Boston Naming Test, and the Benton Visual Retention Test. All neuropsychological tests were administered in a standardized order.

After the initial screening session, patients who met criteria for either Possible or Probable AD (according to NINCDS-ADRDA criteria), were asked to return within two weeks for administration of several additional neuropsychological measures. At the beginning of the second testing session each potential research participant was informed of the current study. The consent form was read and reviewed with each individual. The following neuropsychological tests were administered to the participant during the second testing session: Wechsler Memory Scale, Similarities subtest, and the Apraxia Test. The performance-based functional assessment was then administered. The second testing session took approximately 1 hour to complete.

Sometime during either the first or second testing session, a person involved in the patient's care (most often either a spouse or the patient's adult child) completed the Instrumental Activities of Daily Living Scale. Nearly all neuropsychological and functional testing was carried out by the primary investigator.

Results

Descriptive Statistics

The mean MMSE score for the current sample was 22.02 (SD = 5.11) out of a possible thirty, indicating that the majority of patients were in the rather early stages of dementia. However, mental status scores ranged from 10 to 30, and therefore the overall sample, as a whole, represented a fairly wide range of impairment.

The degree to which participants were reporting symptoms associated with depressed mood was also assessed. The results of the Geriatric Depression Scale indicate that 24 participants (57%) obtained a score that was within normal limits. Therefore, using the cutoff scores developed by Yesavage et al., (1983), approximately half of the sample in this study was not reporting clinically significant symptoms of depressed mood according to this measure. However, fifteen participants, or 36 percent of the sample, obtained scores which placed them within the mild range of depression, and 3 participants (7%) obtained scores which fell within the severe range of depression.

Means and standard deviations for the neuropsychological measures are presented in Table 1. All scores listed are based on raw scores with two exceptions: the Wechsler

Memory Scale and the CVLT Composite Score. Wechsler Memory Scale data is reported in terms of a Standard Score (with a normative mean of 100 and standard deviation of 15), corrected for age. Because it is derived by summing together several individual subtests, it essentially represents a composite score measuring orientation, attention span, and verbal and visual immediate memory. Additionally, due to the numerous scores that can be calculated from the CVLT, a composite variable was created for the purposes of this study. This was done first by obtaining *z* scores for six separate indices (Trail 5, Short Delayed - Free Recall, Short Delay - Cued Recall, Long Delayed-Free Recall, Long Delay-Cued Recall, and the Dscriminability Index), then all *z* scores were summed together to create the composite. An alpha internal consistency coefficient of .95 was obtained for the CVLT composite variable indicating that the chosen CVLT indices could be reliably grouped together to form the composite.

It should be noted that scores on the Trail Making Test, Part B evidenced a strong floor effect. That is, many of the participants could not complete this test without nearly continual help from the examiner and essentially could not perform this task. In these cases, the test was discontinued at four minutes. As a result, there is a restriction in the range of this variable which reduced the likelihood that it would be significantly correlated with other variables. There were cases in which the participants could complete the task independently but performance was very slow; many times these individuals were close to finishing at the four minute cut off time. In these cases, participants were allowed to finish. For this reason an additional variable was included which indicated whether the participant was able to complete Trail Making, Part B and was dummy coded as 1 = yes, 2 = no. Seventeen participants were able to complete Part B, while 24 participants simply could not complete Trail Making, Part B.

Table 2 presents the means and standard deviations for the functional measures (both the IADL and DAFS). Published normative values for a general geriatric population are available for both of these measures. Since the norms for these measures are not age-corrected, but are intended to act as a comparison group for elderly individuals of varying ages, normative values are also included in Table 2. In order to determine if the AD patients in the current study scored significantly more poorly than the normative nondemented geriatric sample a series of one sample t-tests were obtained comparing the current sample means with normative data. Results indicate that the participants in this study performed significantly worse on both the Total Score of the IADL and on all of the individual subscales of the DAFS when compared to the norm. Such findings suggest that the AD patients in this study not only exhibited cognitive impairments but also evidenced functional deficits across multiple domains.

In order to determine whether the IADL and DAFS scales were internally consistent, cronbach alpha correlation coefficients were computed for each measure. Alphas of .93 and .81 were obtained for the IADL and DAFS, respectively. Due to sufficiently high internal consistency, it appeared appropriate to use the ‘Total Score’ on both functional measures, in addition to the individual subscale scores in further analyses.

Data Analysis

Univariate Correlational Analysis. In order to begin investigating the relationship between various neuropsychological, functional, and demographic variables, a series of correlational analyses were carried out. Due to the large number of correlations obtained, it was felt that setting alpha at .05 would likely result in an unacceptably high Type I error rate. However, utilization of a Bonferroni correction, a particularly conservative approach, would likely have resulted in a high Type II error rate. As a compromise, statistical significance was set at .01.

Pearson *r* correlations were computed in order to assess the relationship between the performance-based functional scale (DAFS) and the informant-based functional scale (IADL). These results are presented in Table 3. The correlation between the DAFS Total Score and IADL Total Score was .66 ($p<.01$), indicating a moderate relationship between the overall scores of each measure. Individual subscales of the DAFS and IADL tended to be moderately related.

The associations between the neuropsychological variables and several demographic variables were examined using Pearson *r* correlation coefficients. Table 4 presents the correlations between the neuropsychological variables and MMSE scores, age, education, and scores on the Geriatric Depression Scale. As can be seen, MMSE scores were significantly correlated with all neuropsychological tests, with the exception of the Trail Making Test, Part B. Level of education was correlated with five of the twelve neuropsychological variables, while there were no significantly associations between any of the cognitive variables and either age or degree of depression.

Table 5 presents the correlations between demographic data and functional variables. MMSE scores were significantly associated with most functional variables; specifically, the MMSE was significantly correlated with seven of nine IADL variables and nine of ten DAFS variables. Education was significantly associated with five of the nineteen functional variables while depression was significantly correlated with one functional variable (the ability to follow a map). No significant associations between age and any of the functional variables were obtained.

In order to begin to examine the relationship between neuropsychological performance and daily living skills, the primary purpose of the current study, the associations between neuropsychological test scores and functional measures were obtained using Pearson r correlation coefficients. Table 6 presents the correlations between the neuropsychological variables and performance-based functional domains as measured by the DAFS. For each functional domain of the DAFS, there were significant correlations with multiple neuropsychological measures, suggesting that a variety of different cognitive abilities are important in performing the various functional tasks. Most correlations between neuropsychological test scores and individual DAFS domains were generally in the moderate range (r = .40 to .50, two-tailed), while associations between various neuropsychological measures and the Total DAFS score tended to be somewhat higher (r = .50 to .60, two-tailed). Measures of immediate verbal and visual memory, delayed verbal memory, executive functions, and visuospatial processing were most consistently related to the functional variables. Table 6 presents the correlations between the informant-based functional measure as assessed by the IADL and the neuropsychological variables. Again, each individual IADL domain was associated with multiple neuropsychological variables. In general, the correlations between the IADL and the neuropsychological variables tended to be somewhat lower than the correlations between the DAFS and the neuropsychological variables. Memory was the most consistently related to the IADL variables.

Because education was significantly correlated with many of the variables, partial correlation coefficients, controlling for education, were also computed between neuropsychological and functional variables. Table 8 presents the partial correlations between the DAFS and neuropsychological variables. Even when controlling for education there are still numerous statistically significant correlations. However, many of the correlations which had been significant prior to partialing out education, now fail to reach significance. For example, many of the correlations between the Boston Naming Test and several functional domains failed to be significant, once education was controlled. Table 9 presents the partial correlations between the IADL and the neuropsychological variables. Again, many of the correlations are no longer statistically significant after controlling for education. Both the ability to do laundry and manage finances failed to be significantly correlated with any of the neuropsychological variables. All other functional domains were correlated with one or more neuropsychological variables.

Multivariate Regression Analyses. A series of multiple regression analyses were carried out in order to determine which individual neuropsychological tests best predict each functional domain. Step-wise regression analysis was chosen in order to allow only those variables which contribute unique variance to be entered into the model. In an effort to reduce the number of variables entered into the regression equations only those neuropsychological variables which were statistically significantly correlated with each functional variable ($p>.01$) were entered. Age, education, and depression scores were also available for entry into each of the regression equations in order to examine the contribution of these variables. As with the univariate analyses, alpha was set at .01 in order to help reduce family-wise error. Listed in Tables 10 and 11 are the values for B, standard error, beta, *t*, and *p*.

A total of 19 regressions were carried out using the neuropsychological variables as predictors and each functional domain (including the individual domains/subscales of the DAFS and IADL, as well as the 'Total' scores on both measures) as criteria. Using the DAFS scores as criterion, performance on the WMS (MQ) was most predictive of the ability to tell time and use the telephone (Adj. $R^2 = .21$, $p = <.001$; Adj. $R^2 = .26$, $p = <.001$, respectively). The ability to prepare a letter to be mailed was associated with performance on the direct copy portion of the Rey Complex Figure (Adj. $R^2 = .29$, $p = <.001$). Performance on Trails A was associated with the ability to count currency (Adj. $R^2 = .45$, $p = <.001$). The ability to shop with a written list was predicted by the Apraxia Exam (Adj. $R^2 = .17$, $p = .004$). Performance on the COWAT and the direct copy portion of the Rey Complex Figure was associated with the ability to write a check (Adj. R^2 = .52, p = .005). Performance o Similarities scores, as well as education predicted the ability to balance a checkbook (Adj. R^2 = .52, p = <.006). The ability to follow a map was associated with the Wechsler Memory Scale - Memory Quotient (Adj. R^2 = .30, p = <.001). The Wechsler Memory Scale was most associated with the ability to find previously hidden objects after a 20 minute delay (Adj. R^2 =.29, p = <.001). Lastly, the total score on the DAFS was best predicted by the Wechsler Memory Scale (Adj. R^2 = .54, p <.001).

Next IADL scores were used as dependent variables. Trails-B complete was most predictive of the ability to use a telephone (Adj. R^2 = .29, p=<.001), while performance on the Benton Visual Retention Test best predicted the ability to shop (Adj. R^2 = .39, p = <.01). The ability to prepare a meal was associated with performance of the Benton Visual Retention test (Adj. R^2= .32, p = <.001). The ability to carry out household chores was associated with performance on the Benton Visual Retention Test (Adj. R^2 = .36, p = <.001); the ability to do one's own laundry was predicted by performance on the Benton Visual Retention Test (Adj. R^2 = .23, p = .001). The composite score of the CVLT was associated with the ability to utilize transportation (Adj. R^2 = .28, p = <.001); the ability to manage one's own medication as well as the ability to manage finances were both predicted by performance on the Benton Visual Retention Test (Adj. R^2 = .25, p = <.001; Adj. R^2 = .18, p = <.01). Lastly, the IADL total score (a sum of all subscales) was also predicted best by performance on the Benton Visual Retention Test (Adj. R^2 = .40, p

=<.001).

An important potential problem in interpreting the findings of the regression analyses is the degree of multicolliniarity or interdependency among predictor variables. That is, some of the predictor variables may not have entered into the regression equation because of their shared variance with other predictors. In fact, an analysis of the Pearson correlations among neuropsychological variables (see Table 12) shows that many of the cognitive variables are significantly correlated with one another. In an attempt to deal with this potential problem neuropsychological composite variables were created. Composites were based both on the result of a factor analysis, as well as theoretical presumptions regarding what cognitive ability each test measures. Composite variables were created for memory (which included scores from the WMS, BVRT, CVLT, and Rey Delayed Recall), language (which included the BNT and COWAT), and executive functions (which included the Trail Making Test, both Parts A and B, as well as the Similarities subtest), visuospatial and praxic functions were measured by only one test and thus did not warrant the development of composite variables. Unfortunately, use of these composite variables predicted less variance in each functional domain than entering individual neuropsychological variables. Therefore, the results of the regression analyses using the composite variables are not presented here.

To further analyze the effects of education, age, and depression, another series of stepwise regression analyses were carried out, this time forcing these three variables in as the first step. The results of these analyses were essentially the same as the previous regression analyses reported above. Since education, in particular, was frequently correlated with the functional variables as well as the neuropsychological variables, a third series of regression analyses were carried out in which education was forced in first, and age and depression were available for entry along with the neuropsychological variables. Again, results were essentially the same as the original regression analyses.

Discussion

Despite the fact that the sample, as a whole, was in the rather early stages of AD, functional impairments in multiple areas were noted when compared to normal/nondemented elderly individuals. For example, the AD patient's in the current study demonstrated observable impairments in their ability to tell time, use a telephone, count currency, write a check, balance a checkbook, shop for groceries with a written list, follow a map, and find previously hidden objects as measured by an expanded version of the DAFS. Additionally, the AD patients in this study scored significantly below the norm on the Total Score of the IADL, which also measures many different areas of daily functioning. These findings confirm that, along with the cognitive impairments associated with AD, these individuals also demonstrate significant impairments in their ability to carry out various activities of daily living. Other authors have noted similar findings, for example Loewenstein et al. (1989) also reported that patients with AD exhibited deficits in functional abilities relative to both age-matched controls, as well as elderly individuals with major depression but no dementia. Such findings, of course, are not particularly surprising given that one of the criteria for a diagnosis of AD, as set forth by both the NINCDS-ADRDA and the DSM-IV, includes demonstratable impairments in functional abilities (e.g., impairments in social or occupational functioning or activities of daily living) as a result of the individual's cognitive impairments.

Thus, after demonstrating that this patient population frequently evidences significant functional impairments as a result of their cognitive deficits, the present study sought to investigate the use of neuropsychological test findings to predict AD patients' ability to carry out various activities of daily living. Both univariate and multivariate approaches were utilized in an effort to examine the relationship between neuropsychological, functional, emotional, and demographic information.

The association between functional status and demographic variables was first examined using simple correlational analyses. MMSE scores were moderately associated with performance on both the DAFS and the IADL. Specifically, the significant correlations between the IADL and MMSE ranged from -.38 to -.57, while the correlations between MMSE scores and the DAFS ranged from .34 to .71. Age was not significantly associated with performance on any of the functional domains. However, education was significantly correlated with two IADL domains (the ability to use the phone and the ability to do laundry) and three domains of the DAFS (the ability to use the phone, write a check, and balance a checkbook). No significant associations were found between IADL scores and degree of depression. Degree of depression was significantly associated with the performance-based measure of the patient's ability to follow a map; however, this relationship was in the unexpected direction. That is, those individuals who were more depressed actually performed better on the map task. Similarly, there was also a nonsignificant trend for more depression to be associated with better performance on several of the other DAFS domains. These findings are contrary to what was expected, as depressed mood was presumed to be a possible contributing factor to an AD patient's functional impairments. One possible explanation for the current findings may be that individuals within the early stages of AD (and hence with less cognitive and functional impairments), suffer more depression because they are still cognizant of their failing abilities. In fact, some studies have suggested that depression is more common in the earlier stages of AD (e.g., Reifler, Larson, &Hanely, 1982).

The association between neuropsychological functioning and demographic variables was also examined through the use of the bivariate correlation analyses. Findings revealed that the MMSE is moderately correlated with all neuropsychological tests, with the exception of the Trail Making Test, Part B. Statistically significant correlations between MMSE scores and neuropsychological performance ranged from .22 to .55. Such findings are not surprising as the MMSE is presumed to represent a brief screening of various cognitive functions (e.g., attention, memory, etc.) which are measured more extensively by neuropsychological tests. Education was significantly associated with performance on five of the twelve neuropsychological tests. Specifically, level of education was significantly associated with performance on the Benton Visual Retention Test, Wechsler Memory Scale, the direct copy portion of the Rey Complex Figure Test, Similarities, and the ability to complete Trails B (discounting time). Age was not significantly associated with performance on any of the neuropsychological tests. Similarly, degree of depression, as measured by the Geriatric Depression Scale was not significantly correlated with performance on any of the neuropsychological tests.

The use of simple bivariate correlational analysis was also used to begin to explore the relationship between neuropsychological performance and the demented individual's ability to perform activities of daily living. Overall, the results of these analyses reveal that each of the functional domains, as measured by both the DAFS and IADL, are significantly correlated with multiple neuropsychological variables. In a few cases, a functional domain was associated with only a few neuropsychological tests; however, the majority of daily living skills on both functional measures were significantly associated with seven or more neuropsychological tests.

Of the cognitive functions, memory was most often correlated with the functional domains on both the DAFS and the IADL. In particular, performance on the Wechsler Memory Scale, the Benton Visual Retention Test, and California Verbal Learning Test were most consistently associated with the various functional tasks measured in this study. This suggests that immediate and delayed memory for both verbal and visual information is important in an AD patient's ability to carry out most, if not all, instrumental activities of daily living. Other neuropsychological test which were frequently found to be significantly correlated with the DAFS variables included performance on Trail Making, Part A, the direct copy portion of the Rey Complex Figure, Similarities, and the Apraxia Exam. With regards to the IADL, performance on the Controlled Oral Word Association Test, the Apraxia Exam, and the delayed portion of the Rey Complex Figure were most frequently associated with functional domains. Correlational analyses using both functional measures suggest that, in addition to memory, executive functions, visuospatial abilities, and skilled motor sequencing are important in the successful performance of instrumental activities of daily living.

Because education was significantly correlated with many of the neuropsychological and functional variables, a series of partial correlations, controlling for education, were also obtained. As a result, the number of remaining correlations which reached significance was reduced. However, particularly with the DAFS, many statistically significant correlations remained. As with the simple correlational analyses, results of the partial correlations suggest that measures of memory (particularly the WMS-MQ, BVRT, and CVLT composite) are most often associated with functional measures, followed by visuospatial abilities, praxis, and executive functions.

An examination of the specific neuropsychological tests which were significantly correlated with each functional domain suggest that in some cases results made theoretical sense; however in other cases it was difficult to explain the mechanisms underlying the relationship observed between the neuropsychological and functional measures. For example, in looking at the partial correlations between the neuropsychological measures and DAFS variables, the ability to prepare a letter to be mailed was significantly associated with the BVRT, the direct copy portion of the Rey Complex Figure, and the Similarities subtest of the WAIS-R. Not surprisingly, these results would suggest that visual memory, visual-constructional skills, and reasoning abilities are involved in completing the steps necessary in preparing a letter to be mailed. Similarly, the ability to accurately count out currency was most strongly correlated with performance on Trail Making, Part A; from a theoretical standpoint it is not difficult to imagine how numerical sequencing skills would relate to counting currency. However, other functional tasks were associated with neuropsychological domains not so obviously related. For example, the ability to carry out skilled motor movements (as measured by the Apraxia Test) was significantly related to the ability to read the time on a clock, two seemingly unrelated abilities.

In order to further examine which neuropsychological variables best predicted each functional domain, a series of regression analyses were carried out. Because level of education, and in one case depression, were significantly correlated with some of the functional domains, these variables were also available for entry into the regression equations, along with the neuropsychological variables. MMSE scores were not entered into the regression equations as they were thought to represent brief estimates of neuropsychological functioning and would thus be redundant.

With regard to the performance-based functional assessment, results of the regression analyses indicate that the total amount of variance predicted by the neuropsychological test data in each individual functional domain of the DAFS ranged from 17 to 54 percent. Neuropsychological test performance accounted for 54% of the 'Total' DAFS score. Predictors of patient performance across the DAFS domains differ somewhat.

Specifically, general immediate memory (as measured by the WMS-MQ) was most associated with the ability to tell time, use a telephone, find previously hidden objects, and follow a map. In addition, general immediate memory best predicted overall level of functional status, as measured by the DAFS Total Score; further suggesting that across multiple functional domains, memory is a significant predictor of functional competency within an AD population. Visuospatial abilities (as measured by the direct copy portion of the Rey Complex Figure) best predicted the ability to prepare a letter to be mailed. The ability to count currency was most associated with numerical sequencing skills (as measured by Trails A). Writing a check was most associated with measures of visuospatial and executive functions (measured by the Rey Complex Figure and COWAT). Abstract reasoning (as measured by Similarities), as well as level of education, best predicted the ability to balance a checkbook. Lastly, performance on an apraxia examination, alone, best predicted the ability to shop with a written list.

Overall, immediate memory, visuospatial abilities, and executive functioning tended to be among the strongest neuropsychological predictors of functional status as measured by an expanded version of the DAFS. It is interesting to note that measures of visuospatial/constructional abilities appear to be particularly important predictors of several of those functional tasks which involve writing (e.g., writing an address on an envelop and writing a check). Additionally, various neuropsychological measures of executive functions (e.g., Trails A, Similarities, and COWAT) appear to be important in predicting complex financial abilities such as balancing a checkbook, counting currency, and writing a check. These results are consistent with the findings of Marson and colleagues (1997, 1999) who have also found that executive functions are important predictors of financial competency in AD patients. It should be mentioned that several of the DAFS functional domains had multiple neuropsychological predictors, indicating that a combination of cognitive measures best predicted various functional tasks. Additionally, the results of both the univariate and multivariate analyses suggest that for at least some functional tasks, it is important to take into account the individual's level of education. In the current study, education was significantly correlated with several functional tasks and, according to the regression analyses, was a significant predictor of the ability to balance a checkbook.

In examining those individual functional domains of the DAFS which were best predicted by the neuropsychological variables, it appears that those functional tasks which are most complex or cognitively demanding were best predicted. For example, only a very modest amount of variance in the ability to pick out grocery items with a written list was accounted for by neuropsychological test performance. Alternatively, neuropsychological data accounted for a much more substantial percent of variance in the ability to balance a checkbook. Other authors have also noted that neuropsychological functioning best predicts cognitively complex tasks. For example, McCue, Rogers, and Goldstein (1990) found a low degree of association between self-care, mobility, and physically oriented instrumental activities of daily living and neuropsychological performance. However, these same authors noted a significantly stronger correlation between neuropsychological test scores and activities of daily living which required complex cognitive skills and place heavy demands on memory and problem solving abilities (e.g., using a telephone to obtain information and balancing a checkbook).

Stepwise multiple regression analyses were also conducted using the informant-based functional ratings (the IADL) as criterion and the neuropsychological variables as predictors. The results of these analyses suggest that the association between the IADL and neuropsychological test performance tended to be somewhat more modest than the association between the DAFS domains and neuropsychological variables. The amount of variance in IADL scores accounted for by the neuropsychological test scores ranged from 18 to 40 percent. Again, the 'Total' IADL score tended to be better predicted than the individual IADL functional domains. As with the DAFS, immediate memory (particularly visual memory) was the strongest predictor of performance for most of the IADL functional domains. Specifically, immediate visual memory (as measured by the Benton Visual Retention Test) best predicted the ability to shop, prepare meals, complete household chores, do laundry, manage one's medication, and manage finances. Additionally, the BVRT was also the single best predictor of the 'Total' IADL score, accounting for 40% of the variance. The ability to utilize transportation was significantly associated with both immediate and delayed verbal memory (as measured by the CVLT composite variable). Lastly, the ability to use the phone was most associated with mental flexibility (as measured by Trail Making, Part B).

Consistent with the findings using the DAFS, memory is an important predictor of many of the functional domains measured by the IADL. However, when using the IADL as the functional measure, the BVRT was the best memory-dependent predictor, as opposed to the WMS-MQ, as was the case when utilizing the DAFS. In fact, with the exception of two domains, the BVRT was significantly associated with each IADL domain. Unlike the findings based on the DAFS, those tasks which likely require more complex cognitive skills did not appear to be consistently better predicted by the neuropsychological variables than those tasks which presumably are less complex. For example, financial management (a seemingly quite complex cognitive task) was least associated with neuropsychological functioning.

Taken together, the results of the bivariate correlational analyses and step-wise multiple regression analyses suggest that, overall, there appears to be a moderate relationship between neuropsychological performance and functional daily living skills in an Alzheimer patient population. These current findings support those of previous researchers (Richardson et al., 1995; McCue et al., 1990; Breen et al., 1984; Searight et al., 1989; Dunn et al., 1990; Loewenstein et al., 1995) who also report moderate associations between cognitive and functional abilities in various geriatric populations.

Which specific neuropsychological domains best predict functional status is an important question. Several authors have previously suggested that executive functions (e.g., problem solving and abstract reasoning) may be the strongest neuropsychological predictors of functional status. For example, many researchers have found that within various neurologically impaired populations, employment status (a measure of functional status) was most strongly associated with several measures of executive functioning (Newman et al., 1978; Lezak, 1987; Varney, 1988; Martzke, Swan, & Varney, 1991). Within the dementia/psychogeriatric literature some researchers have also suggested that executive functioning best predicts activities of daily living. In a recent study by Nadler et al. (1993), it was found that the Initiation/Perseveration subtest of the Mattis Dementia Rating Scale, which is often reported to measure executive functions, best predicted observation-based assessment of daily living skills. However, in a later study, although Richardson and colleagues (1995) hypothesized that executive functions would be most highly associated with functional status, they found that visuospatial skills and memory performance best predicted daily living skills. Other researchers have also found that within various geriatric populations memory is highly correlated with functional status (Goldstein et al., 1992; Richardson et al., 1995; McCue et al., 1990). In the current study, memory measures were, by far, most consistently predictive of daily living skills. However, as memory problems are one of the hallmark features of AD, it may be that memory performance reflects, at least to some degree, a general estimate of dementia severity. Along these lines, Loewenstein et al. (1992) found that the MMSE, a widely used measure of dementia severity, was among one of the best predictors of functional status in several different domains using the DAFS. In addition to memory, visual-constructional task and measures of executive functioning also appear to be important predictors of specific functional domains.

Several researchers have argued that, in addition to neuropsychological functioning, psychiatric variables also need to be taken into account when attempting to predict competency in daily living skills within an AD population (Breen et al., 1984; Freels et al., 1992; Nussbaum et al., 1995; Pearson et al., 1989). In the current study, approximately half of the sample was reporting symptoms consistent with at least a mild degree of depression (as measured by the Geriatric Depression scale). However, bivariate correlational analyses revealed that level of depression was only significantly associated with one functional domain (the ability to follow a map). Furthermore, when depression was entered into the regression analyses, it was not found to be a significant predictor of any functional domain. Thus, overall, depression did not seem to play a major role in predicting variance in functional status and when it did, depressed mood actually predicted *better* functional skills. Similar to our results, Freels and associates (1992) failed to find that depressed mood was independently associated with functional impairment in a group of AD patients.

The current study utilized two measures of functional status. Participants were administered a set of standardized functional tasks within the testing setting; in addition, a caregiver familiar with the patient completed a rating scale assessing the patient's ability to perform various activities of daily living. The correlation between the Total Scores on both of these two measures was -.66, suggesting a moderate, but far from perfect, correlation between the two instruments. The question as to which functional measure most closely approximates an individual's actual behavior in the real world is debatable. Both types of functional assessments are associated with advantages and disadvantages. In the current study, performance-based measures of functional status were more strongly associated with neuropsychological performance than informant-based functional measures. Such findings may provide evidence that performance-based methods of assessment are more valid and reliable. Additionally, when using the informant-based measure, the current study did not find that more cognitively complex tasks were more highly associated with neuropsychological test performance. In contrast, we did demonstrate this effect using the performance-based measure and other previous researcher have also found this to be the case (McCue et al., 1990). It should be noted that there are weaknesses associated with performance-based measures. For example, Richardson and colleagues have noted (1994) that one of the weaknesses of the performance-based measures is that tasks are performed in a controlled environment where someone else (the examiner) is prompting or initiating the behavior and supplying all of the needed materials. This is still one step removed from real life in which the patient would have to self-initiate the behavior. As such, performance-based assessments may measure the capacity of the patient to perform the task but not the likelihood the demented individual will actually perform the activity within the home environment. Until further research is available on the reliability and validity of informant-based functional measures verses performance-based measures, it may be wise to utilize both types of measures in the assessment of dementia patients. This way, when discrepancies between the two measures are found, further inquire can be undertaken.

Limitations of the Present Study

A significant limitation of the current investigation was the rather modest number of participants included in the study. This resulted in a poor subject-to-variable ratio and likely effected the power of the statistically procedures employed. A low sample size also limits the generalizability of findings as the particular sample used in this study may not be highly representative of the AD population as a whole.

There are also several problems inherent in the use of stepwise multiple regression analysis. Although this was an appropriate statistical procedure to use in the current study, given the large number of predictor variables (i.e. multiple neuropsychological test scores), it resulted in many predictions being based on only a few (in some cases one) neuropsychological variable. This is due to the multicolinearity or interdependence among the neuropsychological measures entered into the regression equations. Using a stepwise regression approach, the predictor variable most associated with a particular functional outcome variable is entered first into the equation. Only those variables which contribute additional, unique explanatory power are then added into the model. As a result, it is probable that some neuropsychological variables, which were significantly associated with the criterion variable, were never selected because they were highly correlated with variables already entered into the regression model on a previous step. For this reason, it is important to also examine the bivariate correlations between individual neuropsychological measures and functional domains.

An additional limitation of using stepwise regression analysis relates to the method by which variables are selected for entry into the regression equation. The predictor variables are not selected on any a priori, theoretical basis; rather, statistical criteria alone, computed from a single sample, determines which variables are entered into the equation and their order of entry. The results of stepwise regression analyses are therefore very sensitive to the combination of variables which are included. As a result, the findings are highly dependent on the individual characteristics of the sample. This means that the magnitude of the associations found in the current study are subject to reduction with cross-validation, reducing the generalizability of the results. As such, additional studies are needed to replicate and confirm the current findings.

Lastly, it should also be noted that, the high number of analyses undertaken in this study has increased the probability that some analyses will have reached statistical significance by chance alone. Although no control was used to correct for familywise error (e.g., a Bonferroni correction), a more conservative alpha of .01 was utilized in all analyses instead of the more typical .05 level of statistical significance.

Future Directions

Future research investigating the link between neuropsychological performance and functional status in a dementia population should employ a larger number of subjects and should restrict the number of neuropsychological predictor variables. This would improve the power to detect true associations and would allow greater generalizability from the study sample to the patient population.

The use of additional cognitive, behavioral, and/or psychiatric variables may increase the ability to predict the functional status of AD patients. Despite the lack of strong association between depression and functional status, there are likely to be other psychiatric variables which are important predictors of daily living skills. For example, a study by Stern and colleagues (1990) found that within a group of AD patients, functional status was associated with measures of personality and apathy, in addition to cognition. Additionally, Freels et al. (1992) found that two psychiatric problems, namely behavioral disorders (e.g., screaming, wandering, combativeness) and apathy were associated with impairment in activities of daily living, independent of cognitive impairments and various demographic variables. Spector (1997) has argued that the identification of behavioral and/or psychiatric problems which interfere with activities of daily living are particularly important as these symptoms may be amenable to treatment. That is, if the behavioral symptoms can be better controlled, functional status may improve.

In addition to psychiatric and behavioral variables, other cognitive variables, not assessed in the current study, may contribute additional predictive power with regard to the functional status of AD patients. The current findings, as well as the results of previous investigations (e.g., Richardson et al., 1995, McCue, 1990), have suggested that memory is significantly associated with one's ability to perform activities of daily living. However, in both current and past research, only explicit memory has been evaluated.

There is some evidence that implicit memory, particularly procedural learning, is preserved to some degree in the mild to moderate stages of AD (Butters, Heindel, & Salon, 1990). It seems likely that procedural memory, or memory for automatic behaviors, may contribute to an AD patient's ability to continue to perform certain activities of daily living, despite the presence of significant cognitive impairments. Along a similar line of reasoning, Nadler et al. (1993) also suggested that the automatic nature of some functional tasks may help explain the lack of association between cognitive and functional variables. That is, although AD patients exhibit notable functional impairments, the ability to perform activities of daily living may not be as comprised as neuropsychological performance, due to reliance on highly over-learned skills.

The results of this study have important clinical relevance. Overall, the finding from this and other studies suggest that a statistically significant portion of the variance in functional status can be accounted for by neuropsychological test performance. Such results suggest that many of the currently available neuropsychological instruments demonstrate some degree of ecological validity. As such, an individual's neuropsychological test performance can be used to help guide clinical decisions regarding a patient's ability to carry out various activities of daily living. However, it must also be recognized that a substantial amount of variance in functional status is left unexplained when taking into account only neuropsychological test scores and, in the case of this study, degree of depression. As a result some authors (e.g., Loewenstein et al., 1995) have suggested that it is inappropriate to make recommendations regarding an AD patient's ability to perform various activities of daily living based solely on their neuropsychological functioning. These authors recommend that objective measures of daily living skills and/or collateral information from caregivers be used in making decisions regarding a patient's functional competency. The results of this study appear to support these recommendations.

APPENDIX A

TABLES

Table 1

Patient Performance on all Neuropsychological Measures

Neuropsychological Test	Mean (Standard Deviation)
Benton Visual Retention Test (# Correct)	2.93 (1.94)
Wechsler Memory Scale - Memory Quotient	74.21 (14.16)
Apraxia Exam	53.55 (5.65)
Trail Making, Part A	123.02 (80.42)
Trail Making, Part B	238.02 (66.40)
Trails B, Complete	1.58 (.50)
COWAT	16.74 (9.38)
Boston Naming Test	34.27 (14.43)
Rey Complex Figure (copy)	19.98 (10.16)
Rey Complex Figure (delayed recall)	3.57 (4.24)
Similarities	6.90 (6.09)
CVLT Variables	
Trial 1thru 5	18.76 (10.49)
Trial 1	2.52 (2.09)
*Trial 5	4.81 (2.59)
List B	2.48 (1.40)
*Sdfree	1.93 (2.18)
*SD cued	3.52(2.80)
*Ldfree	1.40 (2.01)
*Ldcued	3.19 (2.71)
*Discriminability (%)	68.40 (15.47)
Total Perseverations	2.40 (3.60)
Total Intrusions	12.95 (8.48)

* CVLT scores used to create the Composite CVLT variable.

Table 2

Patient Performance on Functional Measures compared to Normative Data

Functional Measure	Mean (Standard Deviation)	Normative Mean	p
Instrumental Activities of Daily Living			
Using the phone	1.86 (.95)		
Shopping	2.60 (.99)		
Food preparation	2.57 (1.21)		
Completing household chores	2.05 (1.21)		
Laundry	2.21 (1.12)		
Transportation	2.64 (1.36)		
Medication management	2.52 (1.21)		
Financial management	2.69 (.95)		
IADL Total	19.45 (7.73)	24 (3.66)	<.001
Direct Assessment of Functional Status			
Telling time	6.07 (2.23)	8.00 (0.0)	<.001
Using the telephone	6.24 (1.97)	8.00 (0.0)	<.001
Letter preparation	3.31 (2.08)	6.0 (0.0)	<.001
Counting currency	2.48 (1.55)	3.94 (.24)	<.001
Writing a check	3.19 (1.81)	4.94 (.24)	<.001
Balancing a checkbook	.93 (1.09)	2.78 (.55)	<.001
Shopping with a written list	7.57 (1.04)	8.0 (0.0)	.011
*Using a map	4.55 (2.59)		
*Finding misplaced objects	12.05 (6.20)		
DAFS Total	46.31 (15.54)		

*Not part of the original DAFS as developed by Loewenstein et al. (1989). Please not the 'DAFS Total' includes these additional task.

Table 3

Univariate correlations between the IADL and DAFS

	IADL								
	Phone	Shopping	Food	Housework	Laundry	Transport	Medication	Finances	Total
DAFS									
Clock	-.19	-.34	-.17	-.17	-.15	-.35*	-.28	-.31*	-.33*
Phone	-.63**	-.40**	-.25	-.35*	-.33*	-.29	-.40**	-.40**	-.40**
Letter	-.48**	-.63**	-.53**	-.57**	-.38*	-.43**	-.39**	-.46**	-.57**
Currency	-.52**	-.70**	-.55**	-.60**	-.44**	-.61**	-.52**	-.59**	-.67**
Shopping	-.51**	-.41**	-.38*	-.36*	-.30	-.25	-.36*	-.39*	-.49**
Check	-.32*	-.46**	-.36*	-.34*	-.29	-.36*	-.24	-.31	-.39*
Balance	-.43**	-.37*	-.41**	-.38*	-.45**	-.17	-.21	-.26	-.37*
Map	-.42**	-.60**	-.59**	-.64**	-.32*	-.53**	-.47**	-.36*	-.59**
Misplace Obj.	-.40**	-.48**	-.40**	-.41**	-.24	-.55**	-.54**	-.47**	-.55**
Total	-.56**	-.66**	-.54**	-.60**	-.40**	-.59**	-.56**	-.55**	-.66**

Table 4

Correlations between Neuropsychological Variables and Demographic Variables

	MMSE	Age	Education	Depression
BVRT	.61**	.03	.47**	.13
WMS-MQ	.73**	-. 10	.45**	.29
Apraxia	.74**	- .12	.30	.31*
Trails A	-.52**	.23	-.21	-.18
Trails B	-.27	-.12	-.15	-.18
Trails B-Complete	-.47**	.14	-.46**	-.02
COWAT	.55**	- .05	.37*	-.13
BNT	.62**	.33*	.35*	.24
Rey-Copy	.63**	.02	.47**	.16
Rey- Recall	.71**	- .06	.28	-.02
Similarities	.65**	-.11	.42**	.19
CVLT composite	.65**	-.31*	.30*	.05

Table 5

Correlations between Functional Variables and Demographic Variables

	MMSE	Age	Education	Depression
IADL				
Using the phone	-.51**	.04	-.46**	-.19
Shopping	-.46**	.09	-.31*	-.14
Food Preparation	-.39*	.12	.27	-.02
Complete chores	-.46**	.15	-.25	-.10
Laundry	-.38*	.03	-.46**	.10
Transportation	-.57**	.26	-.16	-.04
Med. Management	-.49**	.02	-.14	-.24
Financial Manage.	-.45**	.09	-.20	-.06
IADL Total	-.55**	.11	-.31*	-.12
DAFS				
Telling Time	.53**	.06	.16	.31*
Using Telephone	.53**	.04	.42**	.31*
Letter preparation	.47**	-.05	.30	.19
Count Currency	.60**	-.23	.28	.36*
Shop with list	.34*	.16	.26	.23
Write check	.63**	.09	.49**	-.01
Balance checkbook	.47**	.19	.58**	.09
Using a map	.45**	-.22	.23	.43**
Misplaced objects	.61**	-.05	.19	.31*
DAFS Total	.71**	-.03	.38*	.35*

Table 6

<u>Univariate correlations between neuropsychological measures and DAFS variables</u>

	Clock	Phone	Letter	Currency	Shop	Check	Balance	Map	Misplaced Ob.	Total
BVRT	.27	.40**	.54**	.60**	.23	.57**	.58**	.56**	.41**	.60**
WMS-MQ	.48**	.57**	.50**	.60**	.39**	.59**	.66**	.53**	.56**	.72**
Apraxia	.47**	.48**	.47**	.52**	.43**	.53**	.37*	.38*	.38*	.58**
Trails A	-.39**	-.44**	-.44**	-.67**	-.13	-.48**	-.46**	-.50**	-.38*	-.57**
Trails B	-.13	-.08	-.13	-.07	-.05	-.22	-.41**	-.09	-.15	-.19
Trails B - Complete	-.11	-.45**	-.20	-.34*	-.18	-.36*	-.58**	-.25	-.27	-.38*
COWAT	.26	.36*	.35*	.43**	.29	.57**	.48**	.32	.30	.50**
BNT	.22	.28	.44**	.47**	.13	.42**	.28	.44**	.39**	.42**
Rey -copy	.40**	.45**	.52**	.54**	.32*	.66**	.65**	.44**	.34*	.65**
Rey- delayed recall	.22	.22	.34*	.33*	.22	.45**	.37*	.31	.50**	.40**
Similarities	.29	.41**	.53**	.54**	.31	.51**	.67**	.50**	.46**	.59**
CVLT Composite	.20	.30	.39*	.50**	.32	.45**	.34*	.52**	.52**	.56**

Table 7

Univariate correlations between neuropsychological measures and IADL variables

	Phone	Shopping	Food	Housework	Laundry	Transport	Medication	Finances	Total
BVRT	-.43**	-.64**	-.58**	-.61**	-.49**	-.45**	-.52**	-.45**	-.65**
WMS-MQ	-.39**	-.45**	-.50**	-.44**	-.44**	-.40**	-.45**	-.36*	-.53**
Apraxia	-.48**	-.33*	-.39*	-.41**	-.42**	-.32*	-.41**	-.36*	-.43**
Trails A	.39*	.43**	.35*	.41**	.35*	.37*	.33*	.40**	.40**
Trails B	-.01	.07	.01	-.06	.16	.02	.08	-.09	.03
Trails B (Complete)	.54**	.33*	.28	.35*	.42**	.22	.20	.33*	.31
COWAT	-.40**	-.42**	-.43**	-.33*	-.41**	-.49**	-.35*	-.34*	-.45**
BNT	-.38*	-.46**	-.49**	-.48**	-.39*	-.38*	-.34*	-.30	-.51**
Rey -copy	-.40**	-.33*	-.35*	-.29	-.42**	-.21	-.24**	-.26	-.37*
Rey- delayed Recall	-.39*	-.31*	-.43**	-.41**	-.37*	-.43**	-.44**	-.35*	-.49**
Similarities	-.43**	-.41**	-.40**	-.33*	-.31	-.33	-.18	-.23	-.41**
CVLT Composite	-.39**	-.43**	-.57**	-.48**	-.46**	-.54**	-.33*	-.31*	-.56**

Table 8

Partial correlations between neuropsychological measures and DAFS variables, controlling for education

	Clock	Phone	Letter	Currency	Shop	Check	Balance	Map	Misplaced Ob.	Total
BVRT	.20	.21	.41**	.50**	.19	.40**	.45**	.50**	.37*	.49**
WMS-MQ	.48**	.42**	.38*	.51**	.40**	.43**	.56**	.52**	.55**	.67**
Apraxia	.45**	.37*	.39*	.43**	.47**	.43**	.24*	.29	.38*	.51**
Trails A	-.40**	-.35*	-.33*	-.61**	-.14	-.32**	-.39*	-.50**	-.34*	-.51**
Trails B	-.10	-.03	-.09	-.04	-.01	-.19	-.41**	-.06	-.12	-.14
Trails B - Complete	-.08	-.32	-.15	-.29	-.06	-.21*	-.43**	-.25	-.22	-.30
COWAT	.26	.20	.28	.35*	.27	.47**	.32	.31	.27	.39*
BNT	.14	.11	.27	.34*	.09	.23	.10	.34*	.34*	.34*
Rey -copy	.39**	.28	.42**	.42**	.28	.49**	.50**	.38*	.28	.48**
Rey- delayed recall	.17	.08	.25*	.25	.21	.39*	.27	.25	.48**	.42**
Similarities	.24	.26	.44**	.47**	.25	.37*	.57**	.45**	.41**	.52**
CVLT Composite	.15	.16	.30	.43**	.31	.37*	.21	.48**	.51**	.50**

Table 9

Partial correlations between neuropsychological measures and IADL variables, controlling for education

	Phone	Shopping	Food	Housework	Laundry	Transport	Medication	Finances	Total
BVRT	-.25	-.57**	-.49**	-.54**	-.37*	-.38*	-.47**	-.38*	-.56**
WMS-MQ	-.20	-.33*	-.36*	-.36*	-.30	-.34*	-.39*	-.26	-.43**
Apraxia	-.43**	-.25	-.30*	-.31	-.38*	-.25	-.35*	-.31	-.35*
Trails A	.36*	.37*	.28	.37*	.33*	.35*	.30	.35*	.35*
Trails B	-.09	.02	.03	-.12	.10	.01	.07	-.12	.02
Trails B- Complete	.43**	.25	.24	.38*	.27	.21	.21	.29	.24
COWAT	-.29	-.37*	-.41**	-.33*	-.32	-.52**	-.35*	-.29	-.41**
BNT	-.23	-.36*	-.37*	-.35*	-.30	-.28	-.22	-.21	-.40*
Rey -copy	-.25	-.19	-.25	.17	-.28	-.15	-.19	-.16	-.26
Rey- delayed recall	-.19	-.22	-.35*	-.35*	-.28	-.37*	-.38*	-.29	-.42**
Similarities	-.29	-.31	-.30	-.22	-.14	-.28	-.10	-.14	-.30
CVLT	-.28	-.35*	-.51**	-.42**	-.39*	-.50**	-.26	-.24	-.49**

Table 10

Multiple Regression Analysis Using the DAFS scores as Criteria and Neuropsychological Variables as Predictor

DAFS domain	Predictor Variable	B	Std. Error	Beta	t	Sig
Telling Time	WMS-MQ	7.525	.022	.477	3.43	.001
Using the Telephone	WMS-MQ	7.574	.020	.527	3.773	.001
Letter preparation	Rey-Copy	.112	.027	.551	4.073	.000
Counting Currency	Trails A	-1.323	.002	-.680	-5.713	.000
Writing a check	Rey-Copy	8.581	.022	.484	3.843	.000
	COWAT	7.359	.025	.372	2.951	.005
Balance checkbook	Similarities	.9092	.022	.508	4.104	.000
	Education	.141	.048	.363	2.931	.006
Shopping with list	Apraxia	7.926	.026	.431	3.022	.023
Using a map	WMS-MQ	.102	.024	.567	4.245	.000
Misplaced objects	WMS-MQ	.244	.058	.556	4.178	.000
DAFS Total	WMS-MQ	.818	.121	.74	6.779	.000

Table 11

Multiple Regression Analysis Using the IADL scores as Criteria and Neuropsychological Variables as Predictor

IADL domain	Predictor Variable	B	Std. Error	Beta	t	Sig
Using the phone	Trails B Complete	1.073	.267	.551	4.021	.000
Shopping	BVRT	-.323	.064	-.634	-5.049	.000
Food Preparation	BVRT	-.356	.081	-.578	-4.371	.000
Household chores	BVRT	-.357	.073	-.614	-4.862	.000
Laundry	BVRT	-.304	.085	-.501	-3.569	.001
Transportation	CVLT Composite	-.108	.027	-.541	-4.072	.000
Med. Manage.	BVRT	-.326	.084	-.521	-3.863	.000
Financial Manage.	BVRT	-.219	.069	-.448	-3.173	.003
IADL Total	BVRT	-2.535	.489	-.644	-5.185	.000

Table 12

Intercorrelations Between Neuropsychological Measures

	BVRT	WMS-MQ	Apraxia	Trails A	Trails B	Complete	COWAT	BNT	Rey-Copy
BVRT		.67**	.43**	-.65**	-.09	-.54**	.45**	.73**	.62**
WMS-MQ			.66**	.63**	-.28	-.62**	.54**	.64**	.72**
Apraxia				-.41**	-.10	-.41**	.58**	.61**	.55**
Trails A					-.10	.59**	.42**	.51**	.75**
Trails B						-.06	.04	-.02	-.45**
Trails B -Complete							-.47**	-.50**	-.52**
COWAT								.38*	.46**
BNT									.50**
Rey - Copy									
Rey - Recall									
Similarities									
CVLT Composite									

Table 12 cont.

	Rey-Recall	Similarities	CVLT Composite
BVRT	.62**	.63**	.58**
WMS-MQ	.70**	.74**	.69**
Apraxia	.51**	.52**	.56**
Trails A	.40**	.57**	-.44**
Trails B	-.25	-.33*	-.03
Trails B-Complete	-.34*	-.60**	-.35*
COWAT	.44**	.52**	.53**
BNT	.64**	.64**	.70**
Rey-Copy	.56**	.69**	.48**
Rey- Recall		.55**	.79**
Similarities			.56**

APPENDIX B

CONSENT FORM

Consent Form

I, ____________________________, agree to participate in this study of individuals involved in the evaluation and treatment of Alzheimer's Disease at John Peter Smith Hospital in Fort Forth. The purpose of this study is to investigate issues relevant to the diagnosis of Alzheimer's Disease, its effects on daily functioning, and the response of patients to Aricept (Donepezil) treatment. It is hoped that the information obtained from this study will help lead to improvements in the treatment and diagnosis of this illness. As a participant, I understand that I am agreeing to allow the researchers to use information from my medical records for research purposes. This information will consist of diagnostic test data, family or caregiver ratings of symptoms, and demographic information (i.e., age, gender, race/ethnicity). I understand that the researchers will keep this information confidential and any publication or communication of research findings that may come from this research will not contain information that would identify me as a participant.

I understand that there is no personal risk or discomfort directly involved with participating in this research and that I'm free to withdraw my consent at any time in the study. I also understand that my decision whether or not to participate will not affect the services available to me.

If I have any questions or problems that arise in connection with my participation in this study, I should contact Dr. Ernest Harrell at 565-2671 or Dr. Andrew Houtz at 927-3636.

____________________________ ________________________
Participant Date

____________________________ ________________________
Investigator Date

This project has been reviewed by the University of North Texas (565-3940) and John Peter Smith Committee for the Protection of Human Subjects (927-3636).

APPENDIX C

DEMOGRAPHIC INFORMATION FORM

Demographic Information Form

Age______ Gender: M F

MMSE score_________

Race/Ethnicity: Caucasian African American Hispanic Asian Other________

Education (years)_______

Past Occupation(s) ____

Are you living at home? Yes No

If no, indicate what type of facility: Nursing Home Intermediate Care Facility

If yes, who are you living with?
Alone Spouse Children Other relatives

How long age were symptoms first noticed? ______________________

Do you have any other medical conditions? ___________________________________
____

Is there a history of head injury with loss of consciousness for more than 5 minutes?
Yes No

What medications are you currently taking?____________________________________
____

Have you ever been treated for a psychiatric illness? Yes No
If yes, what diagnosis? ___________________

Has anyone in your family ever been diagnosed with Alzheimer's Disease or had significant memory problems?

Yes No Unknown

If yes, what was their relation to you?

Parent Sibling Grandparent Other_____________

Does the participant still drive a car?   Yes   No

Is the participant able to stay home alone unsupervised?   Yes   No

Is the participant involved in any social activities?   Yes   No

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